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A MOTOR CARRIAGE COMPETITION has been arranged for by the proprietors of "The Engineer," London, England, entries for which must be made by the end of March, 1897. The vehicles are to be delivered at the Crystal Palace, Sydenham (near London) in May, for the preliminary trials and examinations by the judges. The competitive run is for a course of 100 miles out and 100 miles back, and will probably be made on May 31. A wise provision made in the rules is to the effect that as the attainment of high speed is not one of the objects sought, no credit will be given for speeds exceeding 10 miles per hour. The points on which the awards will be made are as follows: 1, Distance run without renewing supplies, and freedom from stoppages for repairs, oiling, etc.; 2, Design and workmanship of machinery and carriage; 3, Safety; 4, Simplicity, durability, accessibility, and freedom from smell and vibration; 5, Time of setting to work and ease of starting; 6, Speed (up to 10 miles per hour) and hill climbing; 7, Steering gear and brakes; 8, Weight; 9, First cost and (to a limited extent), cost of working; 10, General efficiency. The prizes offered are as follows: $1,825 for carriage weighing two tons and carrying four or more passengers; $1,750 for carriage weighing one ton and carrying one, two or three passengers; $1,750 for carriage weighing two tons and carrying one ton of freight; $780 for carriage weighing one ton and carrying 500 lbs. of freight; $600 for a carriage operated by the vapor of oil or spirit, having a specific gravity lower than 0.8%, or a flashing point lower than 73° F. The full conditions of the competition can be obtained on application to "The Engineer," London, England.

THE BOARD OF TRUSTEES OF THE SANITARY District of Chicago, which has in charge the construction of the great Drainage Canal from Chicago to Lockport, Ill., effected a pretty complete reorganization at the annual meeting, held Dec. 8, 1896. This board consists of nine members, five of whom are Republicans in politics, and four Democrats. The president of the board, who is elected by ballot of the nine members, has for the past year been Mr. B. A. Eckhart, a Republican, and the chairmen of the most important committees, who are appointed by the President, have been Republicans. Previous to December, 1895, these same offices had been held by Democrats, the followers of that party being in the majority. The change in the political affiliations of the members which took place at the general election held in 1895, resulted at the annual meeting in the officers being voted to Republicans as above noted. This action aroused considerable partisan animosity, which has continued in a more or less suppressed state during the past year, and at the annual meeting, held Dec. 8, last, the Democrats of the board, with the aid of one of the Republican members, elected a Democrat, Mr. Thos. Kelley, to the office of President, and affected a complete turnover in the chairmanships of the most important committees. This action has increased the intensity of the partisan feeling between the Republican and Democratic members of the board, and in the Chicago press mutual charges of vicious intent and the administration of affairs to further partisan ends, have been flying broadcast. As far as the officially expressed intentions of the majority now in control of the board go, however, the only radical change of policy thus far voiced is the advocacy in the inaugural address of President Kelley of more attention to securing and promoting the waterway features of the canal. To this end Mr. Kelley advocates that all arrangements made for crossing of the canal by bridges shall provide for the present construction, or, at least, the substitution at will, of swing bridges for fixed bridges, and for the planning of all other work with a view to the use of the canal as a waterway. In this connection it may be noted that a convention of delegates from the Illinois River valley towns through which the discharge of the canal will flow was held at Peoria, Ill., Dec. 10, to effect an organization to prevent any change in the law under which the Drainage Canal is being built, and to check any intention of the Board of Trustees to violate or evade the provisions of the law.

THE CHICAGO DRAINAGE CANAL'S engineering force is to be cut down from 142 to 65 men, the work being so far advanced that their services are no longer needed. The new President of the Board of Trustees, Mr. Thomas Kelly, in his inaugural address, referred to the work yet unfinished, a strip 5½ miles long, from Joliet westward, and also the work remaining to be done on the Chicago River, from the lake to Robey St., where the river connects with the main channel. He said that although the government had signified a willingness to deepen the river by drainage and otherwise, the sanitary trustees would probably have to buy or condemn property wherever necessary to bring about the required flow of 300,000 cu. ft., as provided by law. He strongly urged that a plan be immediately adopted to proceed to this work, which should be started as soon as possible.

THE BOSTON SUBWAY has been leased by the Boston Transit Commission, of Boston, Mass., to the West End Street Ry. Co., for 20 years. The rental is 4⅞% on the cost of construction, which will suffice to pay the interest on the bonds and create a sinking fund to pay off the principal in 40 years. In addition to this, the company is to pay quarterly a sum not less than 5 cts. for each car using the subway in either direction. The track, fans, pumps, electric lights, etc., are to be put in by the company and the entire work of maintenance also done by the company.

ELECTRIC LIGHTING FOR SIGNALS, stations, etc., is said to be in contemplation by the New York, New Haven & Hartford R. R. The plan, as reported, is to have power plants at intervals, furnishing light for stations, yards, signal towers, and signals.

AN AIR COMPRESSOR PLANT for shop work has been put in at the Union Pacific Ry. shops at Cheyenne, Wyo. It will be used for operating machine tools, yard derricks, car cleaning, etc. Similar plants will be put in at the other principal divisional points.

THE USE OF DUMMY COUPLERS for hanging up air-brake hose on freight cars has been abandoned by the Southern Pacific Ry. The company will hereafter receive freight cars at interchange points without "dummy couplings," and will decline on and after Jan. 1, 1897, to receive bills for replacing or repairing such couplings.

TRAFFIC ON THE BROOKLYN BRIDGE has been steadily decreasing since 1893, according to the annual report of the trustees, and the reason given for this is the discomfort due to the work of making the changes in the terminals. The total number of passengers for the year ending Nov. 30, 1896, was 43,996,459, as against 44,564,329 in 1895, the financial decrease being $22,514. The changes are now practically completed, however, and an increase in train service is promised.

A RAILWAY CROSSING FIGHT occurred recently at Kingston, N. Y., in which the officers of both roads set their men an example of argument by force, as is too often the case. A few months ago the Common Council granted the Ulster & Delaware R. R. the right to cross the Strand, and on Sunday morning early the track was laid, crossing the Colonial Electric Ry. tracks. Early Monday morning the latter tore out the crossing, and on Tuesday the Ulster & Delaware R. R. put the crossing back. The electric railway had a car running over its track loaded with employees, and the Chief of Police ordered the motorman to stop by order of the Mayor. He refused and was arrested. The Colonial Co. again tried to tear up the tracks, but the Ulster & Delaware R. R. ran a flat car loaded with bluestone over on the crossing and the workmen were obliged to stop. A mob of about 2,000 people gathered and a riot was narrowly averted.

A FIGHT FOR A RAILWAY FRANCHISE is in progress at New Brighton, Staten Island, N. Y. The Staten Island Electric Ry. Co. got hold of an old franchise for a line on Castleton Ave., and started to build the line without a permit, gangs of men being continuously arrested by the police and replaced by the company. The village trustees have rescinded the franchise and given it to the Midland Ry. Co., and trouble is expected in addition to the inevitable litigation.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a head collision of freight trains Dec. 12 at Welder, Tex., on the Southern Pacific Ry. The eastbound train had orders to wait on the siding to let three sections of a westbound train pass, but the second section was mistaken for the last section owing to a fog which prevailed at the time. There were five men killed, and both engines and several cars were wrecked.

A LOCOMOTIVE BOILER EXPLOSION occurred Dec. 4 near Eagleville, Conn., on the New London Northern R. R. The engine was hauling a freight train at the time, and was derailed by the explosion and went down the embankment. Three men were killed.

A BOILER EXPLOSION in the Wilcox Lumber Co.'s mill at Seville, Tex., wrecked the plant and killed six men.

THE LOSS OF THE S. S. "SALIER," of the North-German Lloyds Line occurred off the coast of Spain, Dec. 7. The vessel struck on sunken rocks near the shore in a fog, and went down with all on board, the number of persons drowned being given as about 300, including passengers and crew.

RECENT EXPLOSIONS OF ACETYLENE GAS serve to call attention to the dangerous nature of this much advertised illuminant. The latest is reported in a press dispatch from Berlin, Dec. 14, which states that an explosion occurred in the workshop of an inventor named Geo. Isaacs who was experimenting with processes of making the gas, and four persons were killed. The explosion on Oct. 17 of a cylinder filled with the liquefied gas in the laboratory of M. Raoul Pictet, the well-known chemist and engineer, has been carefully investigated, and the gist of recent reports from abroad is that acetylene is liable to contamination with certain impurities which render it liable to spontaneous explosion. Acetylene appears to be as dangerous from the physical side as from the financial.

THE QUEEN LANE RESERVOIR SUIT, in Philadelphia, has been decided against the city and in favor of the contractors, Filbert, Porter & Co. The suit was brought by the contractors to secure the payment of $137,071, being the 10% of the contract price usually withheld until work is accepted. The reservoir having proved defective the city refused to pay over the balance, claiming that the contractors had done poor work. The defence seems to have been that the contractors followed the specifications, except where ordered or authorized by the city authorities to depart from them.

THE $3,000,000 PHILADELPHIA FILTRATION ordinance has been indorsed by the director of public works and signed by the Mayor. Before anything will be done in the way of construction a decision from the State Supreme Court will be awaited, to learn whether the proposed loan can be legally made. When this is satisfactorily settled and bonds are issued and sold, the council must pass upon the final disposition of the money, so, altogether, the filtration scheme in Philadelphia is by no means past all dangers.

THE PURCHASE OF THE WATER-WORKS OF DULuth by the city has been postponed, at least, by a decision in a lower court, throwing out a large number of votes, and thus giving the majority to the opponents of the project. The city is developing a supply from a new source, and proposed, as we understand it, to buy the distribution system now owned by a company.

AN IRRIGATION POLICY for Colorado has recently been outlined in an open letter by Mr. J. S. Greene, ex-State Engineer of Colorado, and now practicing law Pueblo. In brief, he proposes that the state be divided into natural drainage districts. The people of any of these districts might at any time vote to incorporate their district, the corporation so formed having control of the water and land within the district. The plan is in part dependent on the cession of the arid lands to the several states. Grazing lands would be leased for the benefit of the district, and mineral lands would pay royalties, the sale of such lands being prohibited.

A WATER POWER PROJECT for Portage la Prairie, Manitoba, has been proposed. The plan being to build a dam across the Assiniboine River, south of the city. A favorable report has been made by Mr. Geo. H. Webster, C. E., of that city, but no definite steps have yet been taken.

DIVERS FOR FOUNDATION WORK have been employed at the site of the new building on the north side of Liberty St., near Church St., New York city, owing to the amount of water met with.

ELECTRIC POWER FOR DRAWBRIDGES is to be adopted for all the bridges over the Chicago River at Chicago, Ill., replacing the steam plants now required for each bridge.

A TOWER DERRICK FOR ERECTING STRUCTURAL IRONWORK.

The special conditions under which the erection of ironwork has to be done in the construction of the modern type of steel skeleton building have led to the devising of various improvements in detail adapted to this class of work, and we illustrate herewith a somewhat novel form of erecting derrick which has been used on two or three buildings. The general view, Fig. 1, shows the general arrangement of the derrick, which is simply a four-post tower carrying four booms whose range covers the whole area of the building. The fourth boom had not been put in place when the photograph was taken from which our illustration is reproduced. This view shows the

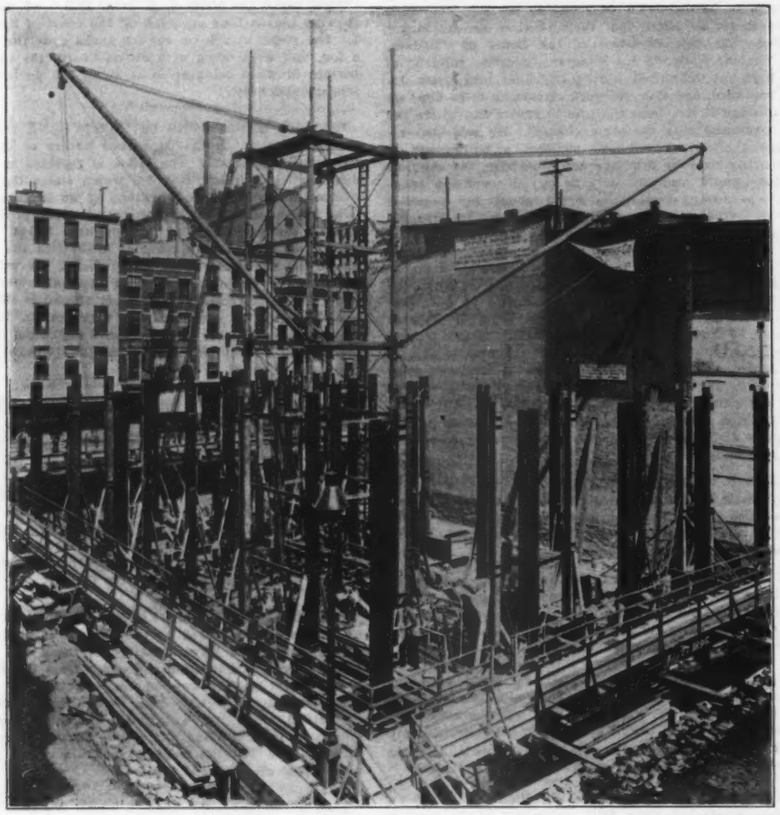


FIG. 1.—TOWER DERRICK FOR ERECTING IRONWORK, WOODBRIDGE BUILDING, NEW YORK CITY.
Levering & Garrigues, Contractors.

derrick as used on the foundations and the two lower stories of the Woodbridge Building, in William St., New York city, and the tower was extended upward as the work progressed, the full height of the derrrick being shown in Fig. 2. The booms are all 60 ft. long, 12 ins. diameter at the upper end, 10 ins. at the lower end and 14 ins. at the middle. They can be lowered to a horizontal position, each boom having thus a reach of 60 ft. and a sweep or range of 270°. The tower was designed to hoist 5 tons on each boom. The contractors for the ironwork of this building were Levering & Garrigues, engineers and contractors, of New York city, to whom we are indebted for photographs and blue prints of the derrick.

BRITISH RAILWAY STATISTICS FOR 1895.

From the general report of the railway companies of the United Kingdom, dated Aug. 10, 1896, and officially presented to Parliament through the Board of Trade, we obtain the following statement relating to the capital, traffic, working expenditure and profits for the year 1895:

The total mileage of British railways at the date of the report was 21,174 miles, of which 9,738 miles were single track; the gain in mileage over 1894 was 266 miles, or 1.3%. The total railway capital, in dollars, was $5,005,551,105, or $236,400 per mile of line operated; the ordinary or common share capital is $1,820,187,025. The total receipts for 1895 were $429,613,510, divided as follows: Passenger receipts, $186,805,810; from goods, $220,174,425; from miscellaneous sources, $22,633,275. The total expenditures for 1895 were $239,383,185, leaving net earnings equal to $190,230,325, a gain of 2.5% over the net earnings of 1894. The receipts per train-mile from traffic were $1.15 30-100, a gain of 0.2% over 1894, and the expenditures per train-mile, exclusive of harbors, etc., were $0.64 64-100; leaving a net earning per train-mile of $0.50 66-100, and a decrease in expenditures of 0.2% per train-mile. The percentage of net earnings on capital was 3.80% as compared with 3.77% for 1894.

The Board considers this showing as satisfactory from every point of view, especially as the small improvement in revenue and net earnings is upon totals which were already the largest on record. In regard to dividends the highest average rate paid, during the last ten years, was 4.32% in 1889; after this date the rate gradually declined to 3.74% in 1893, a rate partly due to the great coal strikes of that year.

From an analysis of the passenger traffic for 1894 and 1895, the following table is prepared:

No. of passengers.	1894.	1895.
First-class	29,821,000	29,990,000
Second-class	60,162,000	58,568,000
Third-class	821,430,000	841,213,000
Total	911,413,000	929,771,000
Receipts from Passenger Traffic.		
First-class	$14,830,000	$15,175,000
Second-class	9,860,000	9,675,000
Third-class	116,380,000	118,980,000
Season tickets	13,240,000	13,800,000
Excess luggage, mails, etc.	28,165,000	29,175,000
Total	$182,475,000	$186,805,000

In recent years the second-class has been abolished on several important lines, and the total decline in this class of receipts has been nearly 27% since 1890. The increase in season-ticket receipts was about 19%. The third-class passenger receipts show an unbroken record of increase for the last 9 years. In 1886 the $80,000,000 mark was just passed, and since that time the actual increase has been equal to 32%. The revenue from third-class passengers now amounts to about three-fifths of the total revenue from passenger traffic.

The receipts from freight, for 1895, were divided as follows: Mineral traffic, $90,880,000; general merchandise, $122,255,000; live stock, $7,040,000; total, $220,175,000. There was a gain over 1894 in these classes of freight of 0.3% in the mineral traffic and 2.7% in merchandise, but a decrease of 3.5% in live stock carried. These sums were earned on the carriage of 240,400,000 tons of minerals and 93,900,000 tons of general merchandise, or a total of 334,300,000 tons, showing a general gain of 3% in volume over 1894. As being of interest in connection with these figures the Board gives the following figures for coal and pig-iron production for the two years:

Item.	1894.	1895.
Coal raised, tons	188,278,000	189,061,000
Pig iron produced, tons	7,427,000	7,703,000
Coal shipped coastwise	17,357,000	16,524,000
Coal exported abroad	31,756,000	31,715,000

The pig-iron production includes that made from foreign ores, and the coal exported excludes that used by steamers engaged in the foreign trade.

The total train-mileage of passenger trains, in 1895, was 184,200,000 miles; for freight trains it was 150,400,000 miles, and the total mileage, including mixed trains, was 338,900,000 miles. The proportion of working expenditure to total revenue, in 1895, was 56%, practically the same as for the preceding year. For many years prior to 1890 this rate remained comparatively stationary at 52 to 53%. In 1890 it rose to 54%, and gradually increased each year until it was 57% in 1893. From an analysis of expenditures for all the railways, in 1895, it is found that these were divided as follows: Maintenance of way, works and stations, $38,300,000; locomotive power, $62,650,000; repairing and renewing rolling stock, $20,100,000; traffic expenses, $74,800,000, making a total of $195,850,000 for the principal items connected with the absolute operation of the railways. The average expenditure per train-mile for all the companies is thus divided:

Item.	1895.
Maintenance of way	10.84 cts.
Locomotive power	17.78 "
Rolling stock	5.72 "
Traffic expenses	21.16 "
General charges	2.06 "
Rates and taxes	4.26 "
Government duty	.38 "
Compensations	
Personal injuries	.18 "
Damage to goods	.32 "
Legal and parliamentary	.36 "
Miscellaneous	.68 "
Total	64.64 cts.

In this connection there is an average decrease of cost of 0.16 cts. per train-mile over 1894. The approximate average cost of coal at the mines, in 1895, was $1.45 per ton, as compared with $1.90 in 1890. The average export price of iron and steel rails, as computed from the quantity and declared value of exports in 1895, was $19.15 per ton, as compared with $27.35 in 1890.

In the analysis of dividends paid in 1895 on $1,820,000,000 of ordinary share capital, it appears that stock to the value of $240,000,000, or 13.2% of the total, paid no dividend. Of the remainder, 29% paid between 5 and 6%; 15.5% paid between 6 and 7%; 11.5% paid between 2 and 3%, and only 0.3% of the total paid between 7 and 8% dividends.

From the general report of the Board of Trade upon railway accidents in the United Kingdom, for 1895, we obtain the following: The total killed by railway accidents was 1,024 and 4,021 people were injured. Of the killed 442 were railway employes and 285 were trespassers; only 83 passengers were killed and 1,109 injured from all causes connected with railways. Of employes 2,654 were injured. The proportion of passengers killed during the year was 1 in 11,202,059, and 1 in 838,387 were injured. In 1894 the proportion was 1 in 7,789,854 killed, and 1 in 780,319 injured. The report details 69 train accidents

during the year, four of which were attended with fatal results.

Among employees 16 were killed and 331 injured while employed in coupling and uncoupling trains; 94 were killed and 1,127 were injured in various shunting operations; 86 were killed and 95 injured while working on the permanent way, and 93 were killed and 148 injured while walking

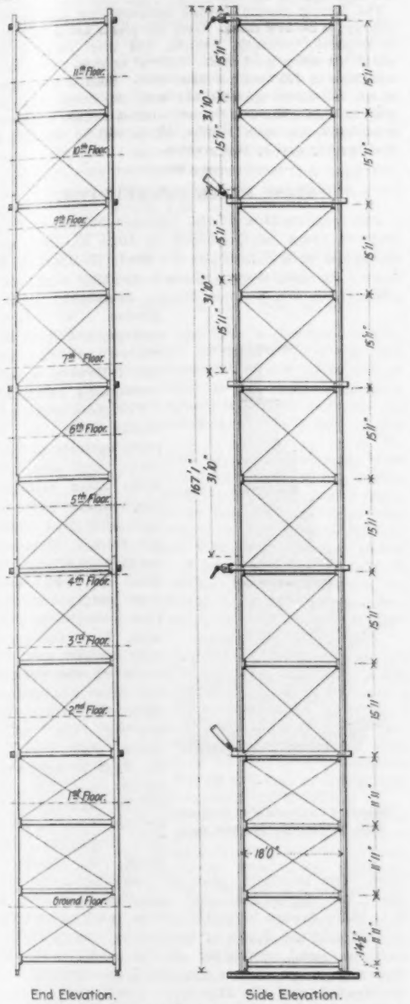


Fig. 2.—Details of Tower Derrick For Erecting Structural Ironwork.

on or crossing the tracks. The total number of men employed on the railways of the United Kingdom, in 1895, was 465,112, divided as follows:

Station masters	7,410
Brakemen and goods-guards	11,881
Permanent-way men	58,781
Gatekeepers	3,292
Engine-drivers	19,281
Porters	45,696
Shunters	7,092
Firemen	19,264
Inspectors	6,805
Passenger guards	6,357
Pointsmen and signalmen	24,381
Laborers	45,882
Ticket collectors	2,795
Mechanics	69,227
Other classes	136,998
Total	465,112

The progress made in the adoption of the absolute block and interlocking system is thus stated in the reports made annually to Parliament. The proportion in which the signal and switch levers had been interlocked on railways was 99.7% in England, 99% in Scotland and 97.7 in Ireland, or 99% for the United Kingdom. The mileage in these several divisions is given as follows:

	Miles—Double.	Miles—Single.
England and Wales	9,325	4,472
Scotland	1,314	1,768
Ireland	613	2,534
United Kingdom	11,252	8,774

By a report dated Dec. 31, 1895, it appears that 94% of all passenger vehicles were fitted with continuous brakes complying with some or all of the requirements of the Board of Trade; and the number of passenger vehicles fitted with pipes and connections only was 5%.

THE WASHING OF BITUMINOUS COAL BY THE LUHRIG PROCESS.*

By J. V. Schaefer, Jun. M. Am. Soc. M. E.**

The composition of fuel is a matter so vitally connected with all commercial and manufacturing industries, that the removal of the impurities in coal has been made a subject of much study and experimental work. Before giving a detailed description of the latest plant built on the Luhrig system the writer desires to consider briefly the nature of these impurities, the means to be employed to remove them, and the advantages of the cleaned coal.

The principal impurities in coal which it is desired to remove are ash in the form of slate, and bone coal and sulphur in the form of pyrites. The larger pieces of slate, bone, and pyrites can be removed by hand picking. Fortunately, all these materials have a specific gravity greater that that of pure coal. It is therefore possible to remove these elements from the small coal by using water in such a way as to float off the coal, which is lighter, leaving the slate, bone, and pyrites to settle. This is the process called washing.

The incombustible matter in coal generally consists of silicate of aluminum and oxide of iron. In blast furnaces the oxide of iron is reduced, but when present in fuel used for generating steam it forms into clinkers on the bars of the furnace grate, resulting in great loss.

Coal ashes often contain about 90% of silicate of alumina. The proportion of silica to alumina is generally ¾ to 2. The latter proportion generally exists in coal with a high percentage of ash. This silicate is almost infusible, and in order to flux it for good working of the furnace it requires an addition of lime.

In blast furnaces on Bessemer iron the slags are generally of the following composition:

Lime, 47%; silica, 38%; alumina, 15%.

The proportion between alumina and lime is about 1 to 3, but if lime be added in the same proportion to the alumina of the ashes of the fuel, the proportion of the bases to the silica will be much greater than in the Bessemer slag. However, to prevent an exaggerated estimate of loss, the lime (in the following calculation) will be only added in sufficient quantity to make the ashes of the fuel as basic as the remainder of the slag produced in the furnace.

Let it be assumed that 22 cwt. of coke, containing:

Carbon, 92%; ash, 5%; moisture, 3%, will produce one ton of Bessemer iron.

The following will show, with this data, what amount of coke will be required when the coke contains:

Carbon, 82%; ash, 15%; moisture, 3%.

The principal elements of the ash being:

Silica, 49%; alumina, 25%; lime, etc., 8%; 22 cwt. of coke with 92% carbon gives 20.24 cwt. of carbon per ton of iron.

Again, 20.24 cwt. of carbon represents 24.7 cwt. of coke when there is 82% of carbon; i.e., with 15% of ash.

The 10% of additional ash in the dirtier coke equals 2.5 cwt., consisting of 1.23 cwt. silica, 0.82 cwt. bases, 0.45 cwt. oxide of iron. The bases take up 0.5 cwt. of silica, leaving 0.73 cwt. to be fluxed by adding lime to the extent of 1.2 cwt., which is equal to 2.2 cwt. of limestone. The total slag due to the extra 10% of ash in the coke will therefore be 3.7 cwt., consisting of 2.5 cwt. ashes plus 1.2 cwt. lime.

	Cwt. Units.
The fusion of 3.7 cwt. of slag requires, according to Bell, 3.7 × 550 =	2,035
To expel the carbonic acid from 2.2 cwt. of limestone requires 2.2 × 370 =	814
To decompose 0.264 cwt. of carbonic acid of the limestone requires 0.264 × 3,200 =	845
Total cwt. heat units	3,694

Taking 4,400 as the number of units developed by 1 cwt. of carbon in the blast furnace, the above will represent 3694 ÷ 4400 = 0.84 cwt. of carbon.

The carbon, therefore, in the inferior coke must be 20.24 + 0.84 = 21.08, instead of 20.24 cwt. Consequently, the coke required with 15% of ash will be 82 : 100 : : 21.08 : 25.7 cwt., or 3.7 cwt. coke for every ton of iron produced, more than coke with only 5% of ash, or about 17% of coke extra.

To this loss must be added the cost of 2¼ cwt. of limestone, which would of itself more than cover the cost of washing. It is evident, therefore, that a great saving can be effected by washing coal to be used for metallurgical purposes.

Connelsville coal contains 0.53% of sulphur. It is considered that any coal which contains in the coke made from it more than 1% of sulphur is not fitted for blast-furnace use. As many coking coals do contain more than 1% of sulphur, it is in these cases absolutely necessary to wash them carefully if they are to be made into coke for blast-furnace use.

The table here given shows a few results which have been obtained by washing coals from different sections of this country, and is interesting in that it shows to what extent ash and sulphur may be removed from coal:

Location.	Ash. Unwashed. %	Ash. Washed. %	Sulphur. Unwashed. %	Sulphur. Washed. %
Sloss, Birmingham, Ala.	10.00	5.80	2.65	1.92
Sopris, Sopris, Col.	22.48	7.20	0.95	....
Big Muddy, Carterville, Ill.	14.25	4.50	1.14	0.97
Blossburg, Birmingham, Ala.	7.68	4.60	2.29	1.48
Mary Lee, Birmingham, Ala.	10.32	6.14	0.89	0.71
Belt, Montana	29.69	7.35	4.32	2.40
Toluca, Toluca, Ill.	18.61	4.92	4.02	2.49
Brazil, Brazil, Ind.	24.32	5.67	....	....
Rogers, Lisbon, O.	12.78	4.90	3.14	1.27
Alexandria, Greensburg, Pa.	10.60	5.00	1.14	0.62
Cherry Valley No. 3, Leetonia, O.	9.88	5.00	3.83	1.72
Comox, Union Bay, B. C.	35.50	8.50	2.15	1.30
Sand Coulee, Montana	25.59	7.25	4.24	1.87
Cokedale, Montana	31.00	5.40	....	....
Crabtree, Greensburg, Pa.	10.60	6.21	1.13	0.617
Athens, Ohio	14.28	6.33	....	....

In a properly conducted washing operation as practised under the Luhrig system, nothing essential to coking is lost. In some of the less thorough systems—if indeed they may at all be called systems—a considerable amount of bituminous matter and pure coal is lost. These losses, however, are inexcusable, and should not be charged to coal washing in general.

Again, the cost of manufacture of coke from dirty coal is greater that that of coke from clean coal. Let us assume that the coal contains 10% of removable ash. As the price of the coke is proportionate inversely to its percentage of ash, it is necessary in this case to maintain a coking plant one-tenth larger than if the coal was washed, in order to produce the same money equivalent.

All that has been stated above applies with almost equal force to coal used under a boiler for generating steam. In the process of burning, the iron, sulphur, etc., in the removable dirt, together with the fixed incombustible matter in the coal, melt together and form a vitrified mass on the grate bars, called clinker. This greatly impedes the passage of air between the bars and causes imperfect combustion. Moreover, when the bars are covered with a firmly adherent mass of clinker they are no longer cooled by a current of cold air, and so become heated, and "burn out." To compensate for these losses an extra amount of fuel must be provided, the cost of which and the cost of removing the ash and repairing grate bars, are items that make the desirability of washing very apparent.

The cost of transportation on a dirty coal is also an element well worth considering In a coal having 18% ash there is probably 10% that might have been left at the mine by a process of washing. In many cases as high as 70% of the price a consumer pays for coal goes for railroad transportation; 7%, therefore, of the price the consumer pays goes for transporting the very thing he doesn't want—a product worse than useless, as it spoils his fire, burns out his grate bars, and costs money to haul away from his ash pit. As this 10% of removable ash can be washed out at the mine at a cost of two to five cents per ton, the transportation charges on it alone will pay for the cost of washing and the shrinkage in volume due to washing. As this washed coal will have 11% greater calorific power the consumer can pay such a price for it as will leave a liberal margin of profit for both consumer and producer. This readily accounts for the fact that wherever it has been introduced washed coal has found a ready market. Parties who once try it are nearly always converted to its continued use.

A thorough system of washing involves the careful separation of the coal into different sizes—No. 1 and No. 2 nut, No. 3 and No. 4 pea, and sludge. It is a universally accepted fact that the best results are obtained by using coal of a uniform size. Therefore the smaller sizes of washed coal often make a much better fire than the run-of-mine or lump coal that has previously been used at a higher price. The much higher efficiency of an evenly graded nut coal over lump coal and the increasing use of mechanical stokers are facts which, in the writer's opinion, will soon compel the coal producer to prepare his steam coal for the demand of the market by crushing and washing. By using the sludge or intermediate product (this term will be fully explained later) it is often possible for a mine operator to use under his own boilers the product for which he has no market, and sell or coke all the remainder.

Freight charges and low prices for small coal often combine to produce conditions where the slack coal becomes a very troublesome affair. It cannot be sold, so it must be hauled to the dump at a cost of considerable money, and often it becomes even there an intolerable nuisance by its firing and clogging streams. In many cases where these conditions exist, a washing plant will convert this expensive slack pile into a marketable product

*From a paper presented at the New York meeting of the American Society of Mechanical Engineers.

**The Link Belt Machinery Co., Chicago, Ill.

which will make a showing on the other side of the ledger.

Again, much small coal is often left in the mine because it does not pay to hoist it. This, of course, means just so much of the coal territory made unproductive. It has been found profitable to hoist this and, by washing, make of it a marketable coal.

The washing of coal is, properly speaking, a process, not a single operation. There is involved in it such an arrangement of various elevators, conveyors, jigs, etc., etc., with respect to their individual and related uses and to their environment that they will work in harmony with each other and handle coal and water to the best advantage.

For fuel purposes, coal must not be broken into fine pieces more than is unavoidable. To this end bar screens and all dumps which tend to break the coal should be avoided, and in their places should be used shaking screens and rotary dumps. The pit cars should be dumped into a hopper at the head of the screen in such a manner as to allow the coal to flow gently on to the upper end of the shaking screen. On this screen the hand picking can be done.

For coking coal it is usually necessary to put in crushers and disintegrators. This is especially true of those coals that are low in volatile matter. When the coal must be reduced to a fine state before coking it should be washed first and disintegrated afterward. If all the product of the mine is coked, and the slate and pyrites occur in large pieces in the lump and egg-coal sizes, these sizes should be hand-picked before going to the breaker, where they are broken to nut-coal size before going to the washer.

All water that has been used should be clarified so as to be used over again. As it takes about a ton of water to wash a ton of coal, there are few localities where it is possible to obtain a sufficient quantity of water to allow it to flow away after being used. Indeed, when it is possible to do this it is not desirable, for the reason that much coal is thus lost, and the damage done to streams by the deposits of fine coal and refuse are apt to cause expensive litigation. The water carrying fine coal should be allowed to settle, the clarified water being used over again, and the fine coal or sludge being saved for coking or for use under the boilers. The water carrying refuse should be treated in the same way, and the refuse, drained of its water, dumped on a pile on the mine property. When these precautions are observed a very small stream of fresh water, usually not over 2½-in. pipe, suffices for washing purposes.

The perfection of the process of coal washing is due almost entirely to the efforts made in this direction by Mr. Carl Luhrig, of Germany; but others have labored in this line, and it will be of value in getting an understanding of the perfection of the Luhrig system to review in a cursory manner some of these other efforts before passing on to the description of a Luhrig washery.

Among mechanical appliances for the washing of coal probably the most primitive consists of a long wooden trough divided by low cross dams at intervals. This sluice is given such an inclination that the water has sufficient force to float the coal over the dams, while the heavier pieces of slate and pyrites are retained and removed at intervals with a rake.

Another appliance consists of an inverted cone-shaped receptacle. Water is forced into this tub near the apex at the bottom, and flowing out at the top it floats over the coal, allowing the slate and pyrites to settle and be removed at intervals by means of valves. In order to facilitate the separation, stirring-arms are put in the tub to keep the water and coal agitated, and so aid the separation.

A percussion table has been used with some success. It consists of a shallow wooden chute or table about 8 ft. long and 3 ft. wide, with sides 6 ins. high. This is made slightly concave upward and suspended by rods in an almost horizontal position. The bottom consists of a sheet of galvanized iron; above this, about 1 in. clear, is a false bottom made of wooden riffles. These riffles are placed close together, with a space of 1-32-in. between, and have their upper edges, pointing toward the higher end of the table, sharpened by the insertion of a piece of sheet metal. This table is allowed to fall forward, and then is thrown back violently against a bumping post. As the coal and water in a mixed stream flow on to the higher end of this table, the upward bumping action throws the heavier particles, which settle down so the riffles can act on them, up and off the higher end of the table, while the clean coal and water flow off the lower end. The receptacle between bottom and false bottom being filled with water, aids the separation and allows the removal of the finer refuse.

All of these appliances have been used with some success, but they are all wasteful of coal and water, their results on different coals cannot be assured in advance, with any reasonable degree of certainty, and they have never been developed into any complete system. Nothing but a running stream will supply the trough washer with water. The inverted cone is tolerably effective with the larger sizes of coal, but inefficient in dealing with smaller sizes and dust. The percussion table requires such careful watching to keep the supplies of coal and water balanced that it is very difficult to keep regulated. The form of the table also requires changing to suit different coals, and as this can only be determined by actual experiment the installation of such a plant proves very troublesome.

By far the best results that have been obtained have been reached by means of various forms of the old Hartz ore jig. The jig consists in general of a box divided vertically into two compartments from the top to a point below the water line. In one of these compartments a plunger plays up and down. The other compartment is closed near its bottom by a screen. Coal is placed continuously on the screen near the partition and water is forced into the back of the other compartment below the plunger. The action of the plunger imparts a pulsating motion to the water, which, acting upward through the meshes of the screen, lifts the lighter parts, allowing the coal to flow out of the front of this compartment near the top, while the slates pass out at a point lower down.

Mr. Luhrig conceived the idea of using pieces of broken feldspar on the screen when fine coal is to be washed. This has proven very successful on fine coal. The refuse which in this case passes out of the bottom of the jig has to pass through the interstices of the feldspar in a tortuous way, and the pulsating water has thus abundant opportunity to act on the mass and lift out the lighter particles of coal.

These jigs have been made in various ways, represented in this country by the so-called Deischer, Stutz, and Stein washers, all the same in principle, but differing in essential details from the Luhrig jigs. It must be kept in mind, however, that success in coal washing does not depend so much on individual machines and appliances which can be made in any good machine shop as it does on the process and the system upon which the whole plant has been built and is operated. The nature of the coal must in every case be taken into account, the purposes for which it is to be used, and the plant designed accordingly. It follows that every plant is different, and imitation of previously carried out plans is generally faulty and disappointing. It is therefore advisable to place the design of washing plants into the hands of an expert who, by training and experience in this particular line of work, is qualified to so systematize and arrange the plant to meet existing conditions as to produce the best results.

The perfection of the Luhrig system of coal washing was the life work of Mr. Luhrig among some of the most dirty and difficult coals of Europe. The system, after being perfected in Germany and covered in its essential details by letters patent, was introduced into England and Scotland, by the Messrs. Merry & Cuninghame at their collieries. Its work at these places was so effective and so far in advance of the results obtained by other processes of washing that it is now almost exclusively used in Great Britain.

Messrs. Cuninghame & Co., controlling the Luhrig patents in the United States and Canada, have introduced the system into this country, and have built successful Luhrig washeries at Carterville and De Soto, Illinois; Belt, Montana; and Union Bay, Vancouver Island. A six-hundred ton plant for coking coal is now building at Greensburg, Pa., for the Alexandria Coal Co.'s Crabtree mine. (Here follows a detailed description of this plant.)

Special attention is called to the following features of this plant: First, the extreme and careful grading into eleven different sizes, and washing each size in a jig especially made and adjusted for it. Second, the washing of the nut coals before crushing to take out the intermediate product. Third, the arrangement of the whole plant with a view to minimizing labor, three men only being required to run it. Fourth, the effective arrangement for settling the water, and the automatic and continuous removal therefrom of sludge and refuse, clarifying the water, and saving all the fine coal dust. Fifth, the effective arrangements for drying the washed coal.

When the matter of washing the Crabtree coal came up for consideration a sample of the coal was selected by the representative of Cuninghame & Co., great care being taken to have the sample represent as nearly as possible the average run of the coal. Part of this was hand-washed, and analyses made of both the washed and unwashed portions. The following results were obtained:

No of sample.	Size.	Kind.	Ash, %.	Sulph., %.	Phos., %.
1	⅛-in. to ¾-in.	Unwashed	10.35	1.098	0.032
2	" " "	Washed	6.88	0.604	0.025
3	1-16-in. to ⅛-in.	Unwashed	10.60	1.139	0.027
4	" " "	Washed	6.213	0.617	0.025
5	Under 1-16-in.	Unwashed	12.400	1.606	0.033
Specific gravity of bone coal					1.30%
Specific gravity of pure selected coal					1.27%
Fixed ash in pure selected coal					2.54%

A previous ultimate analysis of a sample of this coal gave the following results:

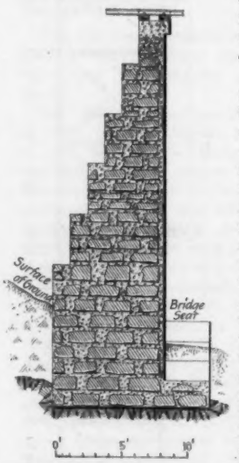
	Bone %.	Pyrites %.	Slate %.
Moisture	1.150	....	....
Vol. matter	26.900	....	....
Ash	21.080	....	....
Sulphur	0.549	28.28	1.008
Fixed carbon	50.321	....	....
Phosphorus	0.072	0.05	0.017
Sp. gravity	1.532	....	....

It is expected that the washing of the coal at this place will be so thoroughly done that the ash in the coke made from the washed coal will be below 10%, and the sulphur below 1%. That this may be confidently expected will be readily apparent when we consider the wonderful results achieved at Union Bay, B. C., where the ash is reduced from 35.5% to 8.5%. The fixed ash in this Comox coal is 7.8%, thus showing that the coal washed to within 1% of the fixed ash in the coal.

The Luhrig system, though comparatively new in this country, is no new thing. Over 200 plants are in daily use in England, Germany, Austria, and other parts of the world, all doing good work. Several of these plants have capacities of 175 tons per hour each. Such is the control which an expert operator has over the results that the Messrs. Cuninghame & Co. are enabled to fully guarantee beforehand the exact results which will be obtained in washing any coal by this process.

STONE FILLED CONCRETE PIER.

The construction of the Cascade bridge, at Burlington, Iowa, was ordered on June 15, 1896, and the work was completed on Sept. 15, 1896, in 92 days. The plans were made in the City Engineer's office, with Mr. Emmet Steece, Assistant City Engineer, in direct charge, and from Mr. Steece are obtained the following details concerning this work.



Section of Concrete Pier for Cascade Bridge, Burlington, Ia.

The piers and abutments were to be built entirely of concrete, and this was done after ordinary methods, except for the last abutment alone. All except this abutment were finished by Aug. 15 and work was commenced on this abutment on Aug. 17. But as it was desired that all work should present the same appearance and the time for placing the metal work was near at hand, it became necessary, for this particular abutment, to devise some means of hastening the work of construction. The previous plan of operation was too slow, as depositing and tamping concrete in 6 to 8-in. layers consumed time; and to attempt to increase the depth of the layers was to endanger the good character of the work. In this emergency Mr. Steece suggested the method here illustrated, and the abutment was completed in 7 days.

The method adopted was as follows: Concrete, made of 1 part cement to 2½ parts of sand and 4½ parts of broken stone, was first deposited in a 4-in. layer. Upon this bed were laid, in a full bed of mortar, wetted rough stone, with the points and projections alone broken off; the spaces between these stones were not less than 6 ins. wide nor less in width than two-thirds the thickness of the thickest stone at the joint. The concrete was then rammed into these spaces and the whole was covered with another layer of concrete not less than 4 ins. thick. In this manner from 40 to 50 cu. yds. of concrete were deposited in a working day of ten hours by a force of 28 men.

The cost of this masonry per cubic yard was as follows:

Saylor's Portland cement	.0.82 bbl. at $2.60	$2.14
Sand	.0.22 cu. yd. at $1.00	.22
Broken stone	.0.52 cu. yd. at 94 cts.	.49
Water		.07
Labor	$1.50 per day of 10 hours	1.19
Large stone	.0.38 cu. yd. at 63 cts.	.24
Foreman		.09
Total cost per cubic yard		$4.44

The total cost of the 278.2 cu. yds. of masonry was $1,235.21, though this cost does not include the excavation nor the lumber used in the forms; the latter were employed again in the construction of sidewalks and box drains in the immediate vicinity. The broken stone had to be hauled two miles, and the charge for hauling alone is given. The city owns a quarry near the bridge site; but

as there was no crusher near it would have cost $2 per cu. yd. to quarry the stone and break it by hand. With a more reasonable cost for the materials Mr. Steece believes this work could have been done for about $4 per yard. The work looked well, though the labor was unskilled; a competent foreman alone being necessary.

This method of reducing the cost of concrete work by imbedding in it large stone, is, of course, not novel; as it is often employed in the construction of dams and other large concrete structures. It was done to a large extent in the building of the Vyrnwy dam for the Liverpool water-works. From the thickness given to this retaining wall, by Mr. Steece, it must be assumed that it is intended to well ram and consolidate the back filling. Even then the thickness is less than a good masonry wall would call for.

GANTRY CRANE OF 200-FT. SPAN AT THE STRUCTURAL IRON YARD OF THE CAMBRIA IRON CO.*

By John W. Seaver, M. Am. Soc. M. E.**

In the latter part of the year 1895, the Cambria Iron Co., of Johnstown, Pa., decided to construct a storage and loading yard for their proposed new structural mill at Johnstown, Pa., and invited several engineering firms to submit estimates and designs for a plant to handle the material that it was intended to store and load in this yard.

Among the firms invited to submit proposals, that with which the writer is connected took up the matter at once, and gave it a great deal of very careful study. The yard it was designed to cover—400 by 800 ft.—was so large that it was evident from the beginning that unless some very economical form of construction should be proposed, the expense of covering the area would be very great. There are several methods by which the desired object can be attained, and each plan was carefully considered and its objections and advantages compared.

A very simple way of covering any area is by the use of stationary derricks with swinging jibs. This, while probably the cheapest construction, is at the same time the most objectionable, on account of its requiring a large number of derricks to cover the surface. In fact, swinging derricks cannot be arranged so as to cover the whole yard, as there is necessarily a considerable area around the foot of the derrick that is unavailable. These objections caused this plan to be dismissed.

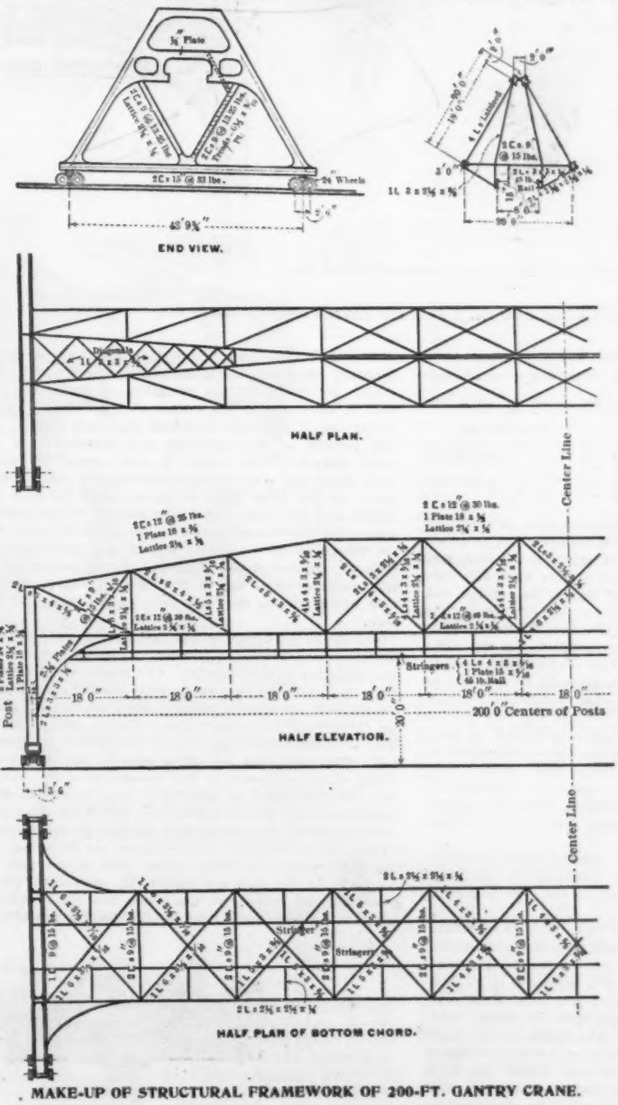
The next plan that was considered was a system of surface tracks, between which the material to be stored would be piled, and on these tracks a number of locomotive cranes could be placed. Two of the objections against the plan of the stationary derrick system could very properly be raised against the second plan with even greater force, as the tracks upon which the locomotive cranes would travel would occupy a very large portion of the yard. The locomotive cranes would be very expensive, and their range of length of jib is quite limited.

A third form of construction, and one that seemed to offer several advantages over the first two plans, consisted in a series of overhead tracks, running parallel to the length of the yard, and mounted on these tracks were to be a number of overhead traveling cranes of the ordinary type. Against this plan could be urged the fact that the supports themselves would take up more or less room, and the foundations, columns and stringers for these supports would be very expensive, and it was proposed to make the cranes of exceptionally long span (100 ft. centers of supports). This span would make the overhead ties or bracing very expensive. Dispensing with the overhead bracing would necessitate the columns supporting the overhead tracks to be sufficiently rigid in themselves to maintain the tracks in perfect alignement, and, in addition to this, they would require exceptionally heavy and good foundations and anchorages. The cranes themselves would be expensive, and, should the surface of the whole yard be covered, which would necessitate four cranes, each 100 ft. span, it would mean the employment of four operators—one for each crane. These were the principal objections to the overhead crane system, but they were deemed sufficient to cause the rejection of this plan in favor of the "gantry" crane system.

This plan contemplates the use of two traveling cranes, each 200 ft. span, running upon tracks on the surface of the ground, parallel to the length of the yard, so that the two cranes cover the whole surface, with the exception of three spaces, one 5 ft. wide down each outside edge of the yard, and one 10 ft. wide down the center. There is one line of track down each outside edge and two lines of track down the center. It was proposed to mount the cranes upon end frames or legs, making them what are commonly called "Gantry Cranes," and to make the legs or end supports of sufficient height to allow a train of cars, with men on top of same, to pass freely underneath. For this purpose the clear height from the top of the rail to the underside of the stringer that the crane trolley traverses was fixed at 20 ft., and as the height from the surface of the yard to the top of the rail is 14½ ins., a clear height from the surface of the ground to the underside of the crane of 21 ft. 2½ ins. is obtained.

The magnitude of these proposed gantries caused the matter to be most carefully considered, both by the Cambria Iron Co. and the Wellman Seaver Engineering Co. After a thorough examination of the plan proposed by the latter they were awarded the contract.

The firm, before submitting their proposal for this crane, very carefully considered all the various forms of



MAKE-UP OF STRUCTURAL FRAMEWORK OF 200-FT. GANTRY CRANE.

cranes, both of the regular traveling and the gantry types that are at present in use, and, after a thorough investigation of the different types, decided upon a form of construction that they believe to be entirely original. It consists of two main girders of the Pratt type, with vertical posts and diagonal tension braces, the bottom chord being straight, and the top chord parallel to the bottom chord for about one-half its length, and then inclining to the end posts of such an angle that the depth of truss at the ends is one-half that at the center. These two main trusses are framed together at an angle of 60°. The top chords have their parallel portions connected with splice and tie plates. The bottom chords are parallel to each other, and separated a distance of 20 ft. The main trusses are 18 ft. deep at center and 9 ft. deep at the ends.

This peculiar form of construction gives the arrangement of the main trusses the appearance of a steep-hipped roof, very long in proportion to its height. A cross section at the center is that of an equilateral triangle, and the cross section of any point between the end posts and where the top chords join each other is that of a trapezoid. Suspended beneath the bracing that separates the bottom chords is a runway for the crane trolley to travel on. This runway consists of riveted I-beams, with T-rails secured to their upper flanges.

The stringers are very rigidly braced to the chords of the main trusses, not only at the panel points, where they were suspended, but also at the middle of each panel.

The horizontal bracing between the trusses consists of a series of floor beams, firmly riveted to the posts of the trusses, and forming the struts of the lateral system.

The diagonal members consist of angle irons riveted to wing plates secured to the trusses and floor beams, these wing plates being bent to conform to the angles of the floor system and the trusses. To prevent any cross strains of the struts resulting from the live load (the weight of the stringers and trolley), it is taken directly from the stringers suspenders up to the top of the posts of the main trusses by means of diagonal suspender angles. These angles also form posts for the attachment of a line of hand railing.

Resting on top of the floor beams are two lines of channel irons parallel to the main trusses. These channel irons form stringers for the foot walk, which extends the full length of the crane. The walk is made of two thicknesses of pine plank with tar paper between. The floor beams also carry the pillow blocks for the main shafting. At the ends of the crane, and in the plane of the trusses, are carried down riveted legs, or supports of box form. These legs are firmly braced to the bottom chords of the main trusses, with large plate iron brackets, well stiffened with angle iron flanges. The legs are also braced to each other crosswise of the crane, with a system of horizontal and diagonal braces, with a stiff tie-beam at the foot of the legs.

The width c. to c. of the trucks supporting the crane is 43 ft. 9¾ ins., forming a wheel base for the crane of a little more than one-fifth of the span, which is sufficient to square the crane on the tracks.

The end frames are formed of plates and angles, arranged so as to present a smooth end surface, the corners of the openings being filled in with curves of large radii.

The top chords are made of two channel irons with a cover plate on top, and latticing on the bottom. The bottom chords are made of two channel irons, latticed on top and bottom, so as to afford no room for lodgment of moisture; this point being carefully kept in view throughout the construction.

The vertical posts of the trusses each consist of four angle irons latticed together. The diagonal members of the trusses are each formed of two angle irons riveted at their intersection. Particular care was paid to the connections of all members.

The loads and strains adopted for this crane were as follows: A live load for trolley equal to 20,000 lbs. To this was added, for impact, 25%, or 5,000 lbs. The weight of the trolley was estimated at 23,000 lbs.—making a total of 48,000 lbs. distributed on four wheels, spaced about 9 ft. centers, bringing a reaction upon each stringer support of 18,000 lbs.

To still further provide for any sudden application of a live load, it was assumed to be equal to 22,000 lbs. applied at any panel point of bottom chord of each truss.

This is largely in excess of any load that will come upon the crane; but it was considered advisable to use it, in view of the fact that the load might catch, thereby bringing a greatly increased weight upon the trolley.

**The Wellman-Seaver Engineering Co., Cleveland, O.
*A paper presented at the New York meeting of the American Society of Mechanical Engineers.

The dead load, weight of trusses and floor, was assumed at 88,000 lbs. per truss, or 8,000 at every point of bottom chord of each truss.

In order to provide for a very large factor of safety in the bottom lateral system, a wind pressure of 20 lbs. per sq. ft. was assumed, or a load of 5,000 lbs. at each panel point of bottom chord. To resist these combined loads, the following limitations of strains were adopted:

For live loads: Tension	12,000	lbs. per sq. in.	net section
Shear	6,000	" " " " " "	
Compression	10,000	"	of gross section
Bearing, rivets and bolts	12,000	"	per sq. in.
For dead load: Tension	15,000	" " " "	net section
Shearing	10,000	" " " " " "	
Compression	12,000	" " " "	gross sec.
Bearings, rivets and bolts	15,000	" " " "	

In all the compression members a proper reduction of the strains was made in all long members, so as to insure the same general factor of safety throughout, and the strains in the bottom lateral system were still further reduced to 10,000 lbs. per sq. in. in tension and 8,000 lbs. per sq. in. in compression. All of these strains are largely in excess of what the writer would recommend for an ordinary crane construction; but the ratio of dead load to live load is so great that it was necessary to observe the greatest possible economy of material to avoid the crane being so heavy that it would be impracticable.

The truss members were not all proportioned to comply exactly with the areas that the above limitations of strains called for. They were never made of less sections, and in several cases the section was increased in order to obtain the necessary stiffness. This will account for the seemingly largely increased area of some of the members over that required by theory.

The minimum speeds of the various motions of the crane are as follows: Traverse of main bridge, 200 ft. per min.; traverse of trolley, 400 ft. per min.; hoist with full load, 20 ft. per min.

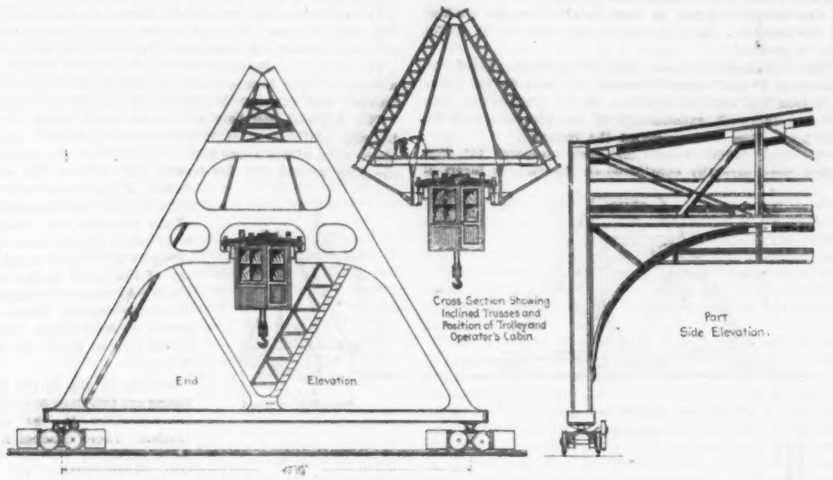
The crane rests upon four trucks; each having four steel tired double flanged wheels, 24 ins. in diameter. The wheels are keyed to steel axles, 5 ins. in diameter. The gage of the track is 3 ft. 6 ins. centers of rails. The journals are 5 ins. in diameter, 7 ins. long, fitted with bronze bearings carried in cast-steel oil-boxes, with ample provision for lubrication. The wheels on one truck at each end are connected by means of a system of shafts and bevelled gear wheels. The gear wheels are steel castings, and are of extra heavy design throughout. The shafting from one truck to the other is 4 ins. in diameter. The couplings are all rigid flanged couplings, tightly keyed to the shafts, and fitted with turned bolts of a tight driving fit. The main shaft, extending the length of the crane, is carried in universal bearing pillow-blocks of very heavy design. These pillow-blocks are bolted to the cross-beams of the floor system, with packing pieces between them and the beams, and are lined up perfectly true and level. The thickness of the packing pieces vary to suit the requirements of each individual pillow-block.

The end bearings, where the main shaft is geared to the diagonal shafts that connect it to the trucks at each end, are carried by compound boxes, so that it is impossible for the main and angular shafts to get out of line.

Special care has been taken with all the bearings to provide ample facilities not only for the lubrication, but for the inspection and removal of any part. For most of the bearings compression grease-cups have been supplied, in addition to the usual lubricating holes and reservoirs.

The top of each truck carries a steel socket or cup, and in this socket is placed a hard steel ball, 6 ins. in diameter.

The bottom of the end supports are also provided with corresponding cupped sockets. The ball rests in a slightly elongated groove; the major diameter of the groove being crosswise to the center line of the truck, and the minor diameter being parallel to the track on which the truck rests. By means of this elongation of the groove, the ball is allowed a slight motion at right angles to the center line of the track on which the truck travels, and this permits of the expansion and contraction of the main girders of the crane. It also allows the trucks upon which the crane travels to be slightly out of alinement, as the balls form universal joints between the trucks and the crane. The arrangement of the gearing connecting the driving shafts to the trucks is such that the vibrations of the trucks around the centers of the balls do not disturb the alinement of the gearing to an appreciable amount, as the centers of the main driving spur wheels are on the same lines as the centers of the balls.

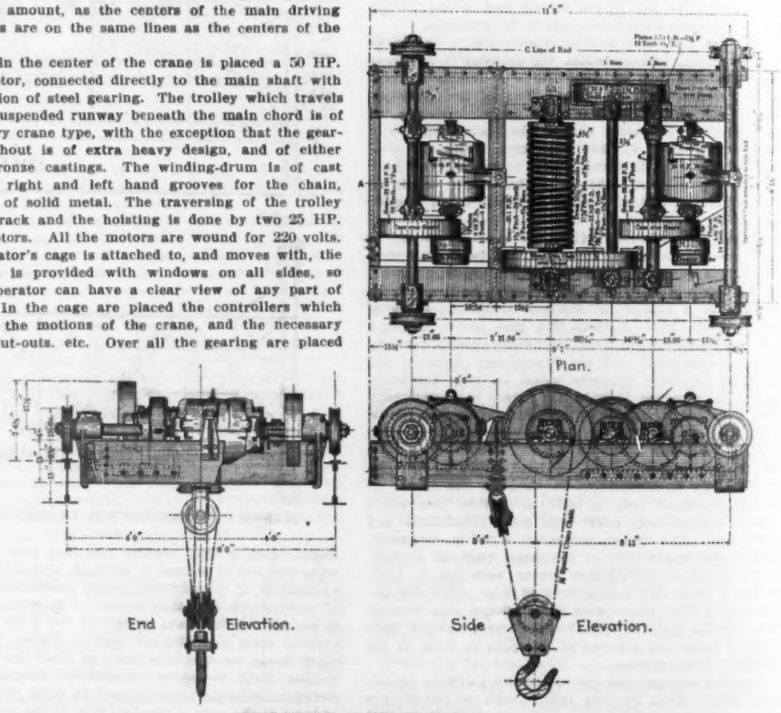

Cross Section Showing Inclined Trusses and Position of Trolley and Operator's Cabin.
Part Side Elevation.
End Elevation.

END ELEVATION AND PART SIDE ELEVATION OF FOOT OF CRANE.

Directly in the center of the crane is placed a 50 HP. electric motor, connected directly to the main shaft with one reduction of steel gearing. The trolley which travels upon the suspended runway beneath the main chord is of the ordinary crane type, with the exception that the gearing throughout is of extra heavy design, and of either steel or bronze castings. The winding-drum is of cast iron, with right and left hand grooves for the chain, milled out of solid metal. The traversing of the trolley upon the track and the hoisting is done by two 25 HP. electric motors. All the motors are wound for 220 volts.

The operator's cage is attached to, and moves with, the trolley. It is provided with windows on all sides, so that the operator can have a clear view of any part of the yard. In the cage are placed the controllers which govern all the motions of the crane, and the necessary switches, cut-outs, etc. Over all the gearing are placed coverings or housings that are readily removable, the coverings being arranged to exclude all moisture or dust. The motors are also encased.

Attached to each truck are two snow-plows, or guards, made of plate stiffened with angle irons. These snow-plows are easily removable, so that access can be had to any part of the trucks.



DETAILS OF CRANE TROLLEY.

The end frames are so arranged that should it be desired to transfer a load from one side of the yard to the other, both cranes can be brought in line with each other by means of removable stops on the trucks, and the trolley from either crane run directly through the end supports and on to the track on the other crane.

THE BUSINESS WISDOM AND RESPONSIBILITIES OF THE ENGINEER.*

About twenty years ago a railway in Illinois became insolvent and a receiver was appointed to take charge of its affairs. To reduce expenses the receiver began by reducing the number of employees, and the first to go, as usual in such cases, was the engineer and all his tribe. For a number of years the road was operated in a cheap, hap-hazard sort of way, when it was sold to an Eastern syndicate, who took immediate steps for reorganization, and I was appointed engineer in charge to rebuild the road. My first work was to thoroughly inspect the entire property and determine what was immediately necessary to make it safe for traffic and also remunerative. I found that the roadbed, bridges, buildings, etc., had deteriorated beyond redemption, that the whole line must be rebuilt. At this time the road had been for about five years in the hands of a receiver, a lawyer.

I labored hard and faithfully for six years, putting the entire road and its branches into first-class condition, and under its excellent management it has so remained to this day. For my services I received about $12,000.

The lawyer remained with the road some years longer than I did. When it passed out of the hands of the master-in-chancery, by which act the office of receiver was abolished, the court ordered that the lawyer be paid from the proceeds of the sale of the road the sum of $125,000.

Now, I do not cite this as a disparagement to lawyers, but as an example of the generally recognized value of a lawyer's services, and it also demonstrates the tenacious grasp with which a lawyer holds upon all properties which he is called upon to control and manage.

This railway property deteriorated under his management. He placed few betterments upon it. Had he employed a competent engineer, much of the deterioration could have been prevented and expensive repairs avoided, besides the traffic would have been heavier and the earnings thereby increased. There were many engineers in the country (most of them out of employment at that time, for it was shortly after the great panic of 1873) who were thoroughly competent to handle the property in a very economical and remunerative manner, making it far more valuable than it proved to be when sold to the Eastern syndicate, and none of them, had the position been offered them, would have refused it at a salary of $2,500 annually. Yet, for all this, the lawyer was paid ten times more

*Extract from an address by Mr. W. F. Goodhue, before the Purdue Society of Civil Engineering.

than was the engineer who repaired his wasteful management.

I see no reason why the engineer should not hold positions of equal responsibility and value with the lawyer. Lawyers hold these positions without becoming engineers, then why should not engineers attain them without becoming lawyers? If both are liberally and broadly educated their chances should be equal. I do not consider the question of natural ability at all. Bright men are not possessed exclusively by any one vocation of this busy world.

I have reasons of my own, born of a long acquaintance and daily contact with the individual, why the engineer has in so large a measure failed to hold his own in the business world, and I give them as follows: Because he is too often the slave to details. He is not always a student of human nature, and thereby fails to manage and understand men. He is too often deficient in business training, the keeping of accounts, etc., and disclaiming all egotism, he is withal a modest, diffident man, too much so for his own good. So many engineers in charge of work want to see and do everything themselves. They have a great horror of errors and mistakes, and are willing to trust nobody. Their heads are full of measurements, weights, elevations, designs, and all the ins and outs of the work in hand. They are a sort of monomaniacs on the rules of construction, and for the time being live and exist upon their work and have no thought or care for anything else. Timid themselves, they teach it to their assistants. The pent-up Utica of their daily life is the limited area of their workshop. They are seldom in the cabinet and always in the field. The lawyer is always in the cabinet and seldom in the field.

Now, a man should be commended for paying strict attention to business—it is almost the only rule of success—but should a man bury himself so deeply in its meshes that he is lost sight of? How would the battle go if the commanding general took a musket and lost himself in the ranks of his army? What would become of the ship if the admiral went below while engaged with the enemy? Victory in either case would be won by the subordinates in command. So it should be with the engineer in charge of work; let him divide the care of details with his subordinates; they will carry them out under the watchful, careful eye of the master, and he will thereby have more time to devote to the general management of the whole business. If the engineer is deeply absorbed in one set of details, he must of course neglect others, and that is what he sometimes does; he will hold firmly to all the details of construction and neglect the accounts belonging to it, which are, in the eyes of nearly all men, the essential elements of business. Some of our greatest engineers have been able business men. Captain James Eads was of this type, and so was the younger Roebling.

The engineer of to-day should be a practical business man, and it is well if he acquire his business training, partially at least, by actual contact with business methods. He should be as well versed in business as the lawyer, the contractor and the makers and dealers in materials, as he is brought daily in contact with one or more of these persons.

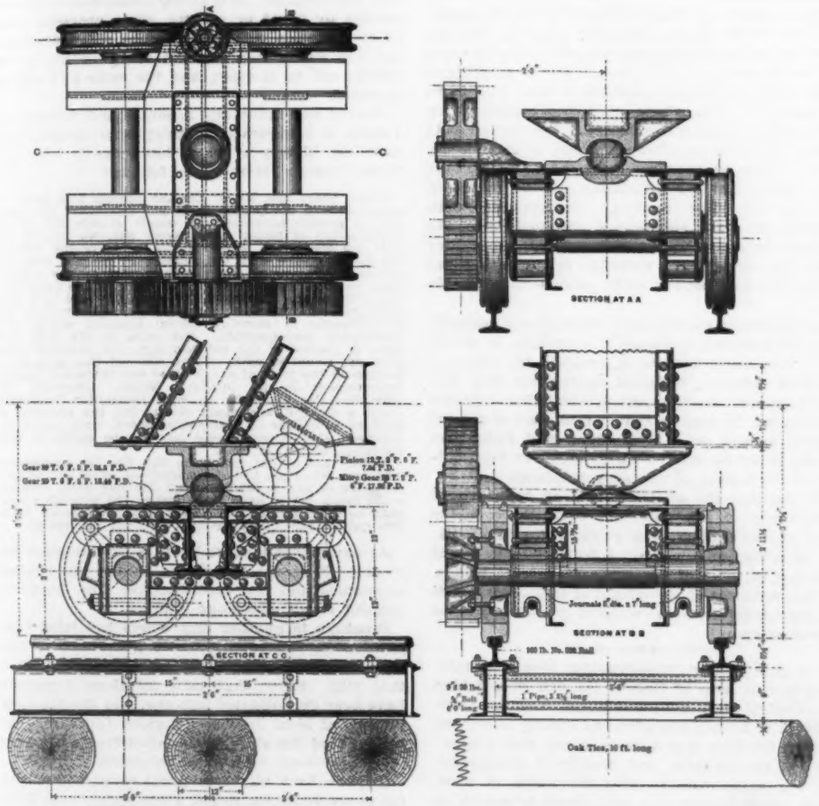
Municipal methods of voting and issuing improvement bonds of various kinds are well worth studying, because nearly all consulting engineers depend upon the issuance of bonds for employement, and it is not pleasant to be thrown out of remunerative work because of a faulty issue of the bonds which are necessary to provide the funds to carry it on. By giving attention to such matters the engineer soon becomes not only proficient in the details of issue and form of bond, but is a very competent judge of what constitutes a legal, solvent bond, and oftentimes can serve his own interests well by pointing out defects, which if allowed to pass unnoticed would defeat their legal issue, and a defective bond issue is quite a common occurrence among our smaller towns and cities. There is not a business or legislative body in the world that can equal the average common council for making serious blunders, and when they do blunder it is generally an expensive affair. Everybody connected therewith suffers more or less either in pocket, or in disappointment because of the resulting delay occasioned, excepting the members of the council, who have no responsibility in the matter at all and cannot be held accountable. They, perhaps, voted as best they knew, and there seems to be no legal form of indictment which can arraign such a condition of mind.

Nowadays wherever you find the common council there you will also find the city engineer, and I must say that I do not always find that sweet harmony which should prevail between them, and it is not to be expected. The rock upon which they most generally split is the difference between good and cheap work. The engineer has perhaps prepared his plans with great care, and when submitted to the council the first thing it wishes to do is to cheapen the cost, and if the engineer won't submit to the pruning process his plans are rejected. The aldermanic line of reasoning seems to be that if the work is not just as strong and durable after the cheapening process, then the plans are defective and the engineer is incompetent.

Upon one occasion I well remember sitting in a council chamber and witnessing a common council voting a form of sewer assessment of doubtful legality, directly against the advice of the city attorney and engineer, and had not the act been subsequently vetoed by the mayor, not one cent of the large assessment could have been collected by the city. Later one of the aldermen said to me: "We voted that assessment act simply to show the city attorney and engineer that they could not run this council." Yet the attorney and engineer both were advising in good faith, and without prejudice, but the minds of that council were not sufficiently elevated to appreciate a firm, disinterested opinion from those who had thoroughly investigated the matter and were well qualified to give their opinions.

This is a fair instance of the stubborn prejudice and ignorance combined which will confront the engineer in his life work. If he is a sensitive, timid man, he will bow before it; if he is brave and resolute, he will hold his own to the end, but will in the meantime receive many knock-downs of humiliation and discouragement. He will find that all bodies of men banded together to build and develop a great property are very much alike, whether it be a board of railway directors, the stockholders of a manufacturing concern, or the common council of a city. These men are not of his kind, they do not comprehend his work, his knowledge nor his methods of reasoning; they are impatient for results, paying results, and will not submit kindly to delays which affect such results, therefore the engineer must be patient with them; he should explain little and offer few apologies, but do all that he can to push the work along to completion; let his actions speak for himself, and these ebullitions of unreasonable impatience will soon pass away. To lose his temper and leave the work upon such occasions is to acknowledge defeat and would be a foolish act, for the next work he may engage would be perhaps quite similar and under the same sort of direction, thus he would be no better off than before.

The engineer must remember that the men, the capitalists who furnish the money and who are directors of many of the great works built and operated in this country are not technically educated men; they are mostly merchants who have acquired fortunes and are seeking investments for their surplus wealth. They are generally first-class business men themselves and it frets and annoys them when they learn that the engineer that they employ is not also a business man. It is a condition they cannot quite understand, because they are unused to such men. Therefore it is quite necessary that the young engineer should go to his life work fully prepared and equipped to meet these men on their own ground; by doing so he will avoid much that is disagreeable and he will also be more successful than have the engineers of this generation who are notoriously unbusinesslike.



TRUCKS AND TRACK FOR GANTRY CRANE.

LEGAL DECISIONS OF INTEREST TO ENGINEERS.

Mining: The Right of Support.

Where the mineral estate in land is severed from the surface by a conveyance, the owner of the former is bound to leave enough of the mineral in place to support the surface, unless the owner of the latter has released his right of support. The release must be by express words or by necessary implication.—Robertson v. Youghiogheny River Coal Co. (Supr. Ct. of Penn.) 33 At. Rep., 700.

Right of Gas Company to Make Reasonable Charges.

When a corporation is chartered with the right to manufacture and sell gas, the right to charge a reasonable rate for all gas furnished is implied, and forms a part of its contract with the state, which cannot be impaired by legislation.—Cleveland Gaslight & Coke Co. v. City of Cleveland (U. S. Cir. Ct. of Ohio), 71 Fed. Rep., 1610.

Negligent Construction of Water-Works.

A water-works company is liable for the damages resulting from the fall of a water tower negligently constructed on its own premises; and where the tower fell and the water therefrom rushed upon a house, overturning a burning lamp, whereby a party was fatally burned, the damages sustained are not too remote in an action brought by the surviving wife and child.—Rigdon v. Temple Water-Works Co. (Ct. Civ. App. of Tex.) 32 S. W. Rep., 828.

Rights of Elevated Road in Streets of City.

An elevated railway company has such a property right in its structure lawfully erected in a street as cannot be damaged by a city without compensation. The construction of a viaduct along a street for the purpose of relieving the traffic along such street is not a mere change in the grade of a street, and an elevated railway company whose structure is interfered with by the viaduct is entitled to compensation.—Manhattan El. Ry. Co. v. City of New York, 35 N. Y. Sup. Rep., 505.

Change of Street Grade: Damages.

Where a city has by ordinance established a new grade of a street, but has done nothing towards raising the street surface to conform to it, a street railway company, which is granted the right to construct a track through the street, is liable to abutting property owners for damages resulting from laying the track at the latter grade, in the absence of an express provision authorizing the act. Stritesky v. Cedar Rapids (Supr. Ct. of Ia.) 67 N. W. Rep., 271.

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ADVERTISING RATES: 20 cents per line agate measure. Want notices, special rates, see page 22. Rates for standing advertisements sent on request. Changes to standing advertisements must be in hand on Monday afternoon; new advertisements, Tuesday afternoon; transient advertisements by Wednesday noon.

Since the publication of our issue of Dec. 3, in which some further reference was made to the work of the Baltimore topographical survey, we have received several letters continuing the controversy upon this subject, which space does not permit us to publish. We are also in receipt, however, of a letter from the Mayor of Baltimore, who is the head of the commission in charge of this work, in which he says:

> The so-called investigation was not authorized, nor have its findings been considered by the commission. The gentleman against whom the charges have been made is still in the position, and at present we have no disposition to remove him for alleged imperfect work.

It appears from the information now before us that the investigation (on which the comments in our issue of Nov. 12 were based) was conducted by a committee of the city councils, which has, as we now understand, no authority whatever over the work. This fact was unknown to us when we made our original study of and comments upon this investigation. Had we been aware of it, we should not have printed its conclusions or based our editorial opinions upon it. The only proper authority to investigate the Baltimore survey, it appears to us, is the commission in charge of the work or the authority which created that commission.

In view of these circumstances we desire to formally withdraw our comments on this survey made in our issue of Nov. 12, and to express our regrets that we were misled as to the non-authoritative nature of the investigation.

A correspondent asks us to suggest topics for college theses in the field of bridge and structural engineering on which investigations would be interesting or useful to the profession. The request is rather a difficult one to fulfil. There are plenty of subjects in this field on which more knowledge is desirable; but in most cases investigations of the results of actual practice, extending over a long series of years, are needed rather than theoretical studies or investigations which can be made in the short time available for a thesis investigation.

Bridge structures of the standard types have been so exhaustively studied that a college student with the time and means at his disposal can hardly hope to add anything valuable to professional knowledge in that field. There is more opportunity, it appears to us, in investigating the applications of iron and steel in building construction. No one who has witnessed the enormous growth which the past few years has seen in the use of iron and steel in buildings can doubt that in the near future we are to see a very large proportion of our stores, mills, and even the better class of residences constructed with steel framework, and the solution of the problems in connection with this new use of steel shapes is likely to have practical value.

For example, there are already a great number of shops and factory buildings constructed with steel framework, and with no attempt at fireproofing. If the reader will turn to page 5 of our current volume, he will find that such a structure may collapse under even a very small fire. Instead of being a good construction to resist fire, as has been supposed, these structures are apparently even more easily injured by an interior fire than if they were built with wooden in place of iron columns.

The question is, what can be done to such structures to render them reasonably fireproof. The expense of ordinary fireproofing systems makes them out of the question; but may it not be possible to apply to the principal members of such structures something in the shape of a non-conductor or fire retardent which should effect the desired end? There are on the market a number of fireproofing paints, and fireproofing solutions. Descriptions of a great number of others can be found in the patent office records. Experiments with samples of these substances obtained from the makers or made up in the college laboratory might be exceedingly valuable in indicating the probabilities of success with constructions of this type.

Again, recent experiments have shown remarkable fire-resisting qualities in concrete. It would be a very useful task to investigate the effect of different cements, different aggregates, and different proportions upon the fire-resisting qualities of concrete. It may be that a thin coat of cement plaster, spread on a very cheap and light wire lathing could be made a fairly effective fireproofing for the frames of iron shop buildings.

We mention the above merely as suggestions; other topics in this field will doubtless occur to many of our readers. For subjects for investigation in bridge engineering, a fruitful topic might be found in some of the types of bascule bridge, and a comparison of the weight of their metal work and machinery with the weights of swing bridges of similar span.

In a note in our "Construction News" supplement in our issue of Dec. 3, the fall of a bridge near Ensley City, Ala., was noted, and the name of Mr. P. S. Milner was given as County Surveyor, not with the idea that he was in any way responsible for the disaster, but merely in accordance with our usual rule to give the name of some official whom contractors and others in search of business may address. As a matter of fact we learn that Mr. Milner had nothing whatever to do with the structure which failed. It was under the charge of the County Superintendent of Public Improvement, an office entirely separate and distinct from that of County Surveyor.

In another item, which recently appeared in our "Construction News" columns, the defeat of bonds for sewer construction in a Massachusetts town was noted and the item concluded with the name of the chairman of the town committee on sewer construction, merely for the convenience of those who might desire to write for further particulars. The gentleman whose name was given, however, in a personal letter to us expressed the fear that the item might be construed as meaning that he was in some manner responsible for the defeat of the proposition. To guard against any mistakes of this sort by those who follow our "Construction News" items, we may say explicitly that the giving of names in connection with these items is done simply as a guide and for the convenience of those who use these items for business purposes; and no other significance whatever attaches to them.

SOME PLAIN WORDS ABOUT CITY GAS SUPPLIES.

In three great cities at the present time the question of gas supply is a subject of public discussion, and in each of them the fruits of a bad system of managing this important business are being made manifest. These three cities are Boston, Brooklyn and New York.

In each of these cities the policy has long been followed of giving franchises to a number of different gas companies in the expectation that competition between them would reduce the price of gas to a figure as low as it could be economically made and sold. Many times has the absurdity of this policy been shown. Many times has it been pointed out that it was bound to result in great injury to every city pursuing it, and that the only parties who would benefit from it would be promoters, stock speculators, and in some cases dishonest city officials. It has been shown time and again that the ultimate result of the chartering of a number of independent gas companies to operate in the same territory will be the consolidation of these companies into one organization; or if actual consolidation be prevented by court or statute, some practical form of co-operation will be devised by which the competition which was to work such benefits to the public will be stopped, and the same end will be attained.

Boston has made two separate and distinct attempts to inaugurate competition in the gas business, the history of which has recently been told in the Boston "Herald," as follows:

> When, years ago, Mr. J. Edward Addicks first made his appearance in the Boston field, and announced his intention of greatly benefiting the people of this city by the introduction of better and cheaper gas, we pointed out that the conclusion would be the union of the competing gas interests, with the subsequent exaction from the people of Boston of the money needed to pay interest upon needless, because duplicate, plants. It is doubtful if Mr. Addicks and his Bay State company would have been permitted to enter Boston if recourse had not been had to influences in securing official approval which were thoroughly reprehensible. But once in the field, and once in control of the old company, the promises made were not complied with. There was not that general reduction in the price of gas, neither was there any marked improvement in its quality. When, afterward, the Brookline Gas Co. came in as a competitor in Boston, again a demand was made calling for the spending of millions of dollars in unnecessary work, upon which expenditure the citizens would later on be called by consolidation to pay interest.
>
> In the case of the Brookline Gas Co. the competition that was permitted had the immediate effect of reducing the price of gas, a change which the Bay State company could much better have made before the Brookline company entered its field than after it was compelled to divide quite a part of its business with the newcomer.

As newspaper readers know, a consolidation has recently been effected of the Boston gas lighting companies and the capitalization has been increased to an enormous figure.

Brooklyn is another city which has tried competition in gas supply. Two years ago no less than five gas companies were doing business in that city. Since that time all these companies have been consolidated into one, and the attorney-general of New York has decided (doubtless correctly) that the state law against trusts is powerless to prevent such a consolidation.

In New York city four great corporations have for many years furnished a gas supply—the Equitable, the Standard, the Mutual and the Consolidated. No competition, at least as respects the price of gas, has existed between these companies for many years; apparently, there has been some private agreement between the several companies by which they have worked in harmony—such perfect harmony, indeed, that the price of gas was kept up by them to the enormously exorbitant figure of $1.75 per M. until it was reduced to $1.25 by an act of the legislature in 1885.

One would have supposed that the experience of the city with competing gas companies which did not compete would have taught the public something; but a half-dozen years ago a new concern came along, the East River Gas Co., and secured a franchise without difficulty, under which it has proceeded to tear up many miles of city streets, many of them newly paved, for the purpose of laying its mains. It has, we believe, sold gas at prices slightly below those charged by the other companies, and as a result a formal union of all the New York gas companies has recently been announced in the newspapers. The course of the stock market bore witness to the correctness of the announcement.

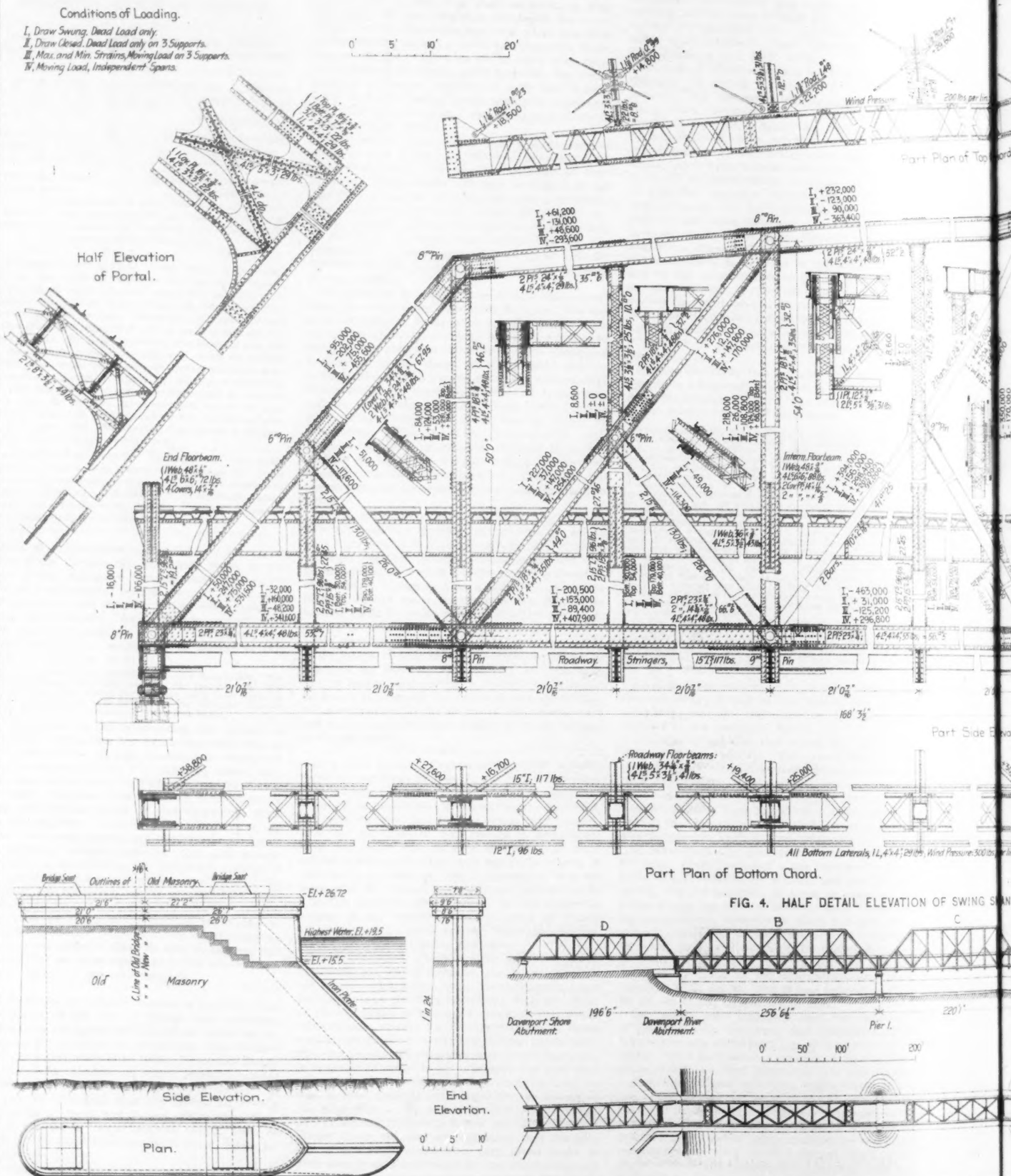


FIG. 2. PLAN AND ELEVATION OF PIERS.

FIG. 4. HALF DETAIL ELEVATION OF SWING SPAN

COMBINATION RAILWAY AND HIGHWA

Ralph Modjeski, Assoc. M. Am. Soc. C. E., Chief Engineer.

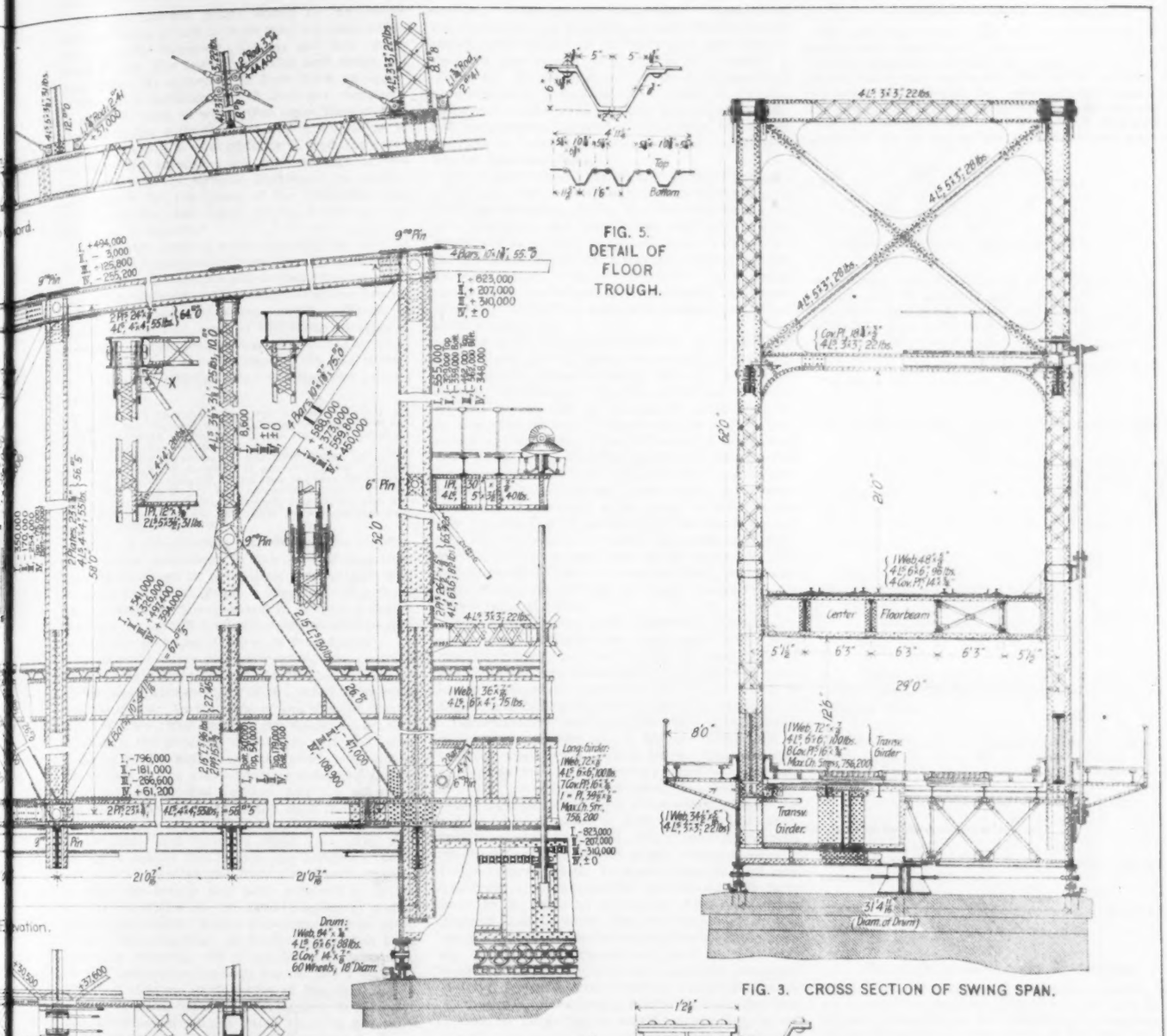


FIG. 5. DETAIL OF FLOOR TROUGH.

FIG. 3. CROSS SECTION OF SWING SPAN.

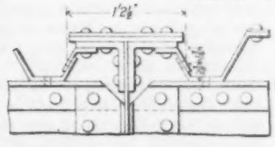


FIG. 6. CONNECTIONS OF FLOOR TROUGHS AND STRINGERS AT FLOOR BEAM.

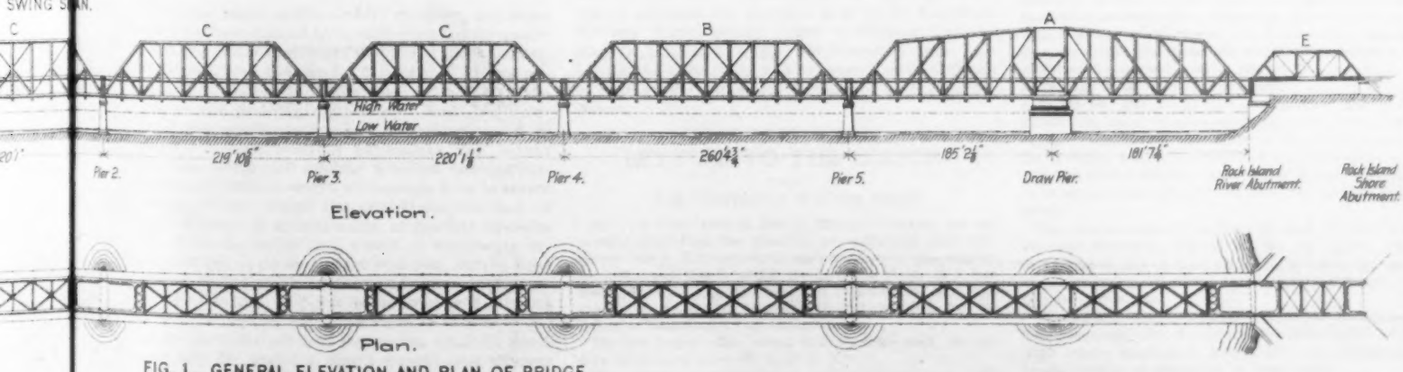


FIG. 1. GENERAL ELEVATION AND PLAN OF BRIDGE.

HIGHWAY BRIDGE, ROCK ISLAND, ILL.

Phoenix Bridge Co., Phoenixville, Pa., Contractors.

CHAS. HART & SONS, LITH., 39 VESEY ST., N. Y.

Here was another object lesson to the people of New York city and to those who are responsible for the public interests. Let us see how much effect it had. For several months past there has been before the Aldermen of New York an application for a franchise by a fuel-gas company. In the very week in which this consolidation was announced the Aldermen granted a franchise to this company by a vote of 26 to 4, and the committee which recommended the passage of the ordinance had the sublime assurance to present as a reason for the grant of the franchise that "if competition will force prices down, by all means let us have it."

The childish folly of such a remark in view of the actual circumstances is apparent enough. That the aldermen themselves are perhaps not so ignorant of the elements of municipal business principles as the above quotation would indicate is shown by the fact that at the same meeting a resolution was adopted authorizing an inquiry into the feasibility of the city owning its gas works, and in the preamble to this resolution the following occurs:

> Whereas, The recent combination between the old gas companies and the new best illustrates the futility of expecting reductions in the price of gas from the establishment of competing companies; and
> Whereas, This municipality has itself failed to secure cheap street lighting, because, in advertising for competitive bids for that purpose, it has been the invariable experience that there is not real competition, but that the different companies apportion among themselves the different districts of the city, and offer non-competitive bids for the respective districts.

Query: If the aldermen understand the "futility of expecting reductions in the price of gas from the establishment of competing companies," why did they proceed to grant a franchise to a fuel-gas company on terms which in several features run counter to well-settled principles that should govern the granting of all such franchises?

Fortunately, there has been during the past ten years an enormous advance in the public appreciation and understanding of the value of municipal franchises. In the case of the present proposition to give away another gas franchise in New York city, the press of the city is a unit in condemning it, the Mayor and the city's law officers are certain to use every effort to defeat it, and as it is only by a legal quibble that the aldermen can claim the right to grant such a franchise, anyway, there is a good prospect that the aldermen's action may be of no effect.

Since the above was in type the aldermen themselves have recalled the franchise above referred to from the Mayor and have referred it to the special committee on the establishment of a municipal gas supply, whose appointment was noted above. The aldermen, of course, deny that their action in granting the franchise was influenced by any motives but anxiety for the city's welfare; but they offer no explanation of the fact that a motion to make the franchise limited in duration instead of perpetual was voted down by the same vote by which the franchise was passed, and another motion to sell the franchise to the highest bidder (other companies having, in fact, already made better offers than the company to which the franchise was given) was defeated by the same vote.

Turning again to the general question, the three cities we have named have each pursued for many years the policy of competition in the gas business. What has been the result? Millions of dollars expended in laying duplicate lines of mains in the streets and building unnecessary and badly located gas works; millions of dollars expended in tearing up and relaying pavements for laying needless mains and making needless connections. Millions of dollars worth of damage done to street pavements for which the city taxpayers had to pay. Millions of dollars worth of gas lost by leakage from the badly laid mains of companies organized not to do an honest business, but to float shares on the stock market and make their promoters wealthy; and finally unnumbered millions of dollars paid by gas consumers in excessive gas rates above the price at which gas could be made and sold for under a single honest and efficient administration. Such is the net result of a half century of bad management of the gas industry in American cities.

What are the correct principles on which the gas supply of a city should be managed? Experience has developed one principle at least which can be stated without fear of contradiction, and that is that the gas supply of a city is of necessity a monopoly. Every attempt ever made to establish competition in it has resulted finally in failure, and because this plain fact has been so commonly and persistently ignored in American cities, the dwellers in them have to bear an enormous and wholly needless burden.

The cities of Great Britain and of the Continent have been far wiser in their administration of their gas supplies. There the essential monopoly of a municipal gas supply has long been recognized, and as a result the inhabitants of nearly all the principal European cities are furnished with gas at a cost of 50 to 75 cts. per M. ft., whereas, the average cost of gas to the consumer in American cities of similar size will average nearly or quite double this.

There are two general systems of controlling a city's gas supply when the monopoly principle is recognized, either of which can give admirable results. In the one, the city owns and operates its gas supply just as it does its water supply. In the other the city grants an exclusive franchise to a corporation for a limited term of years, and fixes in the franchise the quality of the gas, the prices at which it will be furnished to public and private users and the tax (preferably a percentage of its gross earnings) which shall be paid to the city. At the end of the term of the franchise the city has the option of taking the plant at an appraised valuation, and can either undertake the supply itself or make a contract with some company, either the old one or a new competitor for a new term of years.

Each of the plans above described has advantages; local circumstances may make sometimes one, sometimes the other preferable; but either is vastly better than the system which has been commonly pursued by American cities, and which is based on a false and obsolete political economy.

Unfortunately the problem before American cities at the present day is not the simple one of building anew on a correct basis. The mistakes and errors of two generations cannot be wiped out at once. The law does not annul the existing franchises because they were given away or sold for a song by an ignorant or dishonest board of aldermen a score of years ago. What each city should do, therefore, will depend on the circumstances in which it finds itself. In some cities faithful city attorneys or other public spirited officials have seen to it that no perpetual franchises were granted, and in these cities the introduction of a correct system will be a comparatively simple matter. In other cities grants have been thoughtlessly made by which companies have acquired perpetual rights to use city streets, often as a free gift. To undo this manifest wrong is a difficult task, but that it will be permitted to exist unremedied to the end of time seems too preposterous to be believed.

The experience of American cities has abundantly shown the folly of granting perpetual franchises. If the way is not yet open by which they may be annulled, we can at least prevent further folly of this sort. The organic law of every state should prohibit the grant of any public franchise for any longer period than a quarter-century. Such a provision would not interfere with any legitimate enterprise and it would save millions of dollars of "unearned increment" to the public purse.

LETTERS TO THE EDITOR.

Coal Consumption of a Gas Engine.

Sir: In your issue of Dec. 3 different opinions are expressed regarding the quantity of anthracite coal consumed per I. HP. per hour with a Dowson gas engine. In this connection I would mention the result of a test made by the City Engineer in Copenhagen, Mr. Ch. Ambh, on a Dowson gas engine manufactured by the Tuxen & Hammerick Co., Copenhagen.

The test lasted eight hours, with variable load, the engine developing from 38 to 47 I. HP.

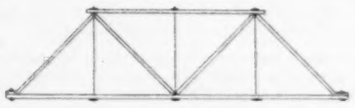
The average consumption of anthracite coal was 0.855 American lbs. per I. HP. per hour, measured in the generator.

Yours very truly,
K. Moller-Holst, C. E.

138 East 29th St., New York city, Dec. 9, 1896.

A Curiosity in Bridge Designs.

Sir: An item in your paper recently reminds me of a case where a large railway company a few years ago absorbed a small one on which "practical" men were employed rather than engineers. The resident engineer of the larger road reported that several of the bridges on the absorbed line wabbled excessively (in a vertical plane) under the passage of the trains of the large road, and a sketch of one of the bridges in question was sent to



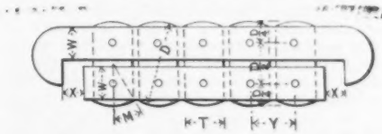
headquarters, with the report of the "engineer"—that it seemed as if the stringers had all the carrying capacity that there was in the bridge, and it was undoubtedly getting too weak to be in service. The sketch herewith shows that an engineer may be about as "practical" as the practical man.

H. V. Hinckley, M. Am. Soc. C. E.

Topeka, Kan., Dec. 3, 1896.

The Design of Segmental Rollers for Expansion End of Bridge Spans.

Sir: In drawing segmental rollers for the expansion ends of bridges the dimensions indicated by W, X and Y on the accompanying sketch, must be made such that the bridge may expand or contract the required amount. I have worked out the following formulas which give values of



W, X and Y, such that when the bridge expands or contracts A inches the rollers will bind in each of the three following ways:

$$Y = \frac{I}{\cos \theta}; \quad X = \frac{D}{2} \sin \theta; \quad W = \frac{D}{2} \cos \theta;$$

$$\theta = \frac{A}{2} \cdot \frac{360}{D\,\pi}.$$

M must be equal to at least $\frac{A}{2}$ ins.

I have made tables for 6-in., 8-in., 10-in. and 12-in. rollers for necessary values of A.

Yours very truly,
F. P. McKibben.

Mass. Inst. of Tech., Boston, Dec. 9, 1896.

The Electrical Conductivity of Aluminum.

Sir: In your issue of Nov. 26 you make calculation upon the electrical conductivity of aluminum rods used by the Pittsburg Reduction Co. for transmitting the current from its generators in the power-house on the lower bank of the Niagara River to the pot-room on the upper bank of the Niagara River. These conductors are of ⅝-in. diameter, and in lengths of 350 ft. In your calculations as to the relative cost of aluminum to copper, you make the cost per pound of aluminum 1.8 times that of copper rods. This is somewhat in error, as you base your calculations upon the elecctrical conductivity of aluminum at 54.2% that of pure copper, while, as a matter of fact, we are furnishing aluminum in large quantities for electrical conductors with guaranteed electrical conductivity of 63% of copper. The actual test of the electrical conductors used by us at Niagara for our line shows this conductivity, and with our purest aluminum we have obtained results of 64% of pure copper; tests having been made by Mr. Chas. F. Scott at the electrical testing laboratory of the Westinghouse Electric Co., East Pittsburg. As a matter of fact, aluminum is as cheap as copper when at two times the cost of copper per pound.

The tensile strength of the rods used for our Niagara line was something over 21,000 lbs. per sq. in., with an elongation of 27% in 2 ins. and 10% in 8 ins. Similar rods of copper ordinarily would have a tensile strength of 40,000 lbs. per sq. in.

The relative longer distance which will be allowed between supports with the aluminum conductors as compared with copper conductors, makes the use of aluminum a special matter of advantage in many cases.

For further data regarding aluminum electrical conductors which we are using at our Lower Niagara Works, we have to inform you that the current is carried at 280 volts pressure, and that there are over 500 of these ⅝-in.

rods of 350 ft. length. The rods are painted with an insulating varnish and are strung in a wire tower which is attached to the penstock carrying the water to the turbine.

Very respectfully,
The Pittsburg Reduction Co.
Alfred E. Hunt, President.

Pittsburg, Pa., Nov. 30, 1896.

(On receipt of the above letter we wrote Mr. Hunt stating that the figure 54.2 for conductivity of aluminum was given on the authority of Mr. Lazare Weiler, who is considered good authority. Mr. Hunt's reply is given as follows:—Ed.)

Sir: Weiler's tables on the conductivity of aluminum are in error. The results were probably obtained with samples of impure metal. With all alloys, the conductivity is materially reduced. Any aluminum over 98% pure will have over 54% electrical conductivity, so far as our experience goes.

We have had a good many electrical conductivity tests made, and with our purest aluminum the results run over 64½%. Very respectfully,

The Pittsburg Reduction Co.
Alfred E. Hunt, President.

The New York Railroad Commission's Decision Concerning the Catskill, Cairo & Windham Electric Ry.

Sir: I would like to take exception to your note in your issue of Nov. 26 upon the recent refusal of the New York Railroad Commission to grant a permit for construction to the Catskill, Cairo & Windham Electric Street Ry. Co. In the first place, it is a street railway, and would be for the accommodation of the people living along the Catskill and Cairo turnpike, along which it is proposed to run, while the Catskill Mountain R. R., being a steam road, cannot, even if it attempted to do so, accommodate the people, except at stated stations along its route. The proposed road would not parallel the Catskill Mountain R. R. in the general meaning of the term for at least one-third of its length. They would both start from Catskill Point on the Hudson, but the steam road follows the Catskill Creek, while the electric road is intended to be a street railway, and would follow the main street of Catskill through that village and, continuing on through, would follow the turnpike, passing through three villages of considerable size and passing through Cairo at a distance of about eleven miles from its starting place would go on to Windham at the summit of the Catskills. The Catskill Mountain road passes through neither of the villages, and has no stations for them, with the exception of South Cairo and Cairo, where one branch ends, but the main line extends to Palmville, which is entirely off the line of the proposed road. The present road is not self-supporting, both because it is at arm's length from the villages and because it charges exorbitant freight rates and passenger fares; for the latter the charge is 10 cts. per mile, thus barring almost all but summer boarder travel. The local travel at present goes by stages, of which there are several all the year and in summer hundreds every day for the summer boarder traffic. The freight is now also carried by wagons. Without taking away any of the present traffic of the Catskill Mountain road an electric road would be a profitable investment. I write the above from a knowledge gained by living on the proposed route for a number of years, and knowing every foot of the ground of both the present steam road and the proposed electric road. I enclose a clipping showing the Catskill opinion.

I am, yours respectfully,
Lewis B. Sebring, C. E., Cy. Engr., Schenectady, N. Y.

(The clipping enclosed is from the Catskill "Examiner" of Nov. 21, and is as follows:—Ed.)

The proposed road manifestly is not parallel to the C. M. Ry., which does not go to Jefferson, Leeds and South Cairo villages, has no stations at Leeds or Jefferson, and only at a distance from South Cairo.. It does not and cannot, under the prohibitory rates for fare and freight, accommodate the public during the portion of the year it is in operation, and there is no doubt that the traffic thus tabooed would make an electric railroad a profitable venture. That it would be a great convenience and is practically a necessity nearly every business man in the village and residents along the proposed road attest. No evidence was before the commissioners to show that the road would not pay, except that given by persons either directly or indirectly interested in the Catskill Mountain Ry. That the commissioners should make such an outrageous decision in favor of monopoly is bringing anathemas from the general public upon them.

The Ownership and Control of Water in the Irrigable West.

Sir: You are entitled to the thanks of Western irrigators for your timely discussion of our unsatisfactory conditions. The attention of the East is what is needed, and a proper appreciation of our situation is greatly to be desired. To this end I wish to call attention to one or two features of our water laws not generally understood, and not dealt with in your editorial of December 3.

(1) Transfers of lands to the arid states will not add to or take away from the control over streams already exercised by these states.

The act of Congress of July 26, 1866, recognized the validity of local laws and customs in the control of streams and in the appropriation of their waters, as is shown by the following extract (Sec. 2,329, Rev. Stat. U. S., 2d ed., 1878):

Whenever, by priority of possession, rights to the use of water for mining, agricultural, manufacturing, or other purposes, have vested and accrued, and the same are recognized and acknowledged by the local customs, laws, and the decisions of the courts, the possessors and owners of such vested rights shall be maintained and protected in the same (Act of July 26th, 1866).

Under this sanction, rights have been acquired under state and territorial laws by virtue of which important streams have, for all practical purposes, passed from public to private control. The rights thus acquired have been upheld in both state and national courts of appeal, so that the right of Congress to reassume control of the water supply of these states is gravely questioned.

In Wyoming state ownership of streams is not a matter of implication. Congress conferred such ownership by specific grant and in the following manner:

The state constitution of Wyoming was framed, adopted by the people of the territory and submitted to Congress for the examination, and ratification or rejection, of that body. The approval of that instrument by Congress made Wyoming a state without Presidential proclamation or further action by the people of the territory. Whatever powers or authority that instrument asserted were thus absolutely ratified and confirmed by Congress. Sec. 1, of Art. 8, of the State Constitution reads as follows:

The water of all natural streams, springs, lakes or other collections of still water within the boundaries of the state are hereby declared to be the property of the state.

Every legal authority whom I have heard discuss this question has agreed that by the ratification of this article by Congress the title of the state to the waters of its rivers became as complete as it is to the Capitol building at Cheyenne, and that Congress can now no more legislate about the management of one than it can of the other.

The state owns the streams, the nation owns the land; neither one is of value without the other, and without some concert in their management and disposal there can be no satisfactory development of our agricultural resources.

There is no such concert of action at present. Our land laws were framed for the humid East. They ignore the grazing lands; they make no provision for communal or concerted action in the reclamation or management of the irrigable land; they fail to protect capital in the construction of irrigation works, and by increasing the risk add to the cost thereof, and, in the end, to the burdens of water users. State laws for the management of water are impotent. State ownership of streams is of no consequence so long as the state has no land on which to apply them.

This situation is full of menace for the future. Having no land on which to apply the water there is a lack of local appreciation of its ultimate value, which makes it easier for individuals looking to the future to secure the passage of laws permitting the transfer of these streams to private ownership.

It is worth considering that the state which has most complete control of its streams is most carefully guarding its property. In no other of the arid states are the limitations on water rights as clearly drawn or public control as rigorously exercised as in Wyoming.

(2) Your statement that the act granting one million acres to each of the arid states requires that water rights should be inalienable therefrom, requires amendment. No such condition is contained in the national act. The Wyoming law accepting the donation makes land and water inseparable in this state.

(3) So long as separate ownership of land and water continues there can be no application of the principle of the Wright District Law to the reclamation of public land. The success of this act, or the liability to reclaim lands through any district or communal organization, depends on authority to pledge the land for the money required for its improvement, and in the right to subject all the lands in the district to the regulations which the district or community may find necessary. Present land laws permit neither of these things.

If human experience has any value it has certainly sufficed to show the evils and abuses of our present land system. The history of every irrigated country in Europe shows the necessity for uniting with land the right to the water which reclaims it. Under our system the control of these two joint agents of production is divorced at the outset. We have tried this system long enough to know that its results are in many cases pernicious, and in all insufferably inadequate.

The state of Wyoming has within its borders the headwaters of four of the great rivers of the arid region. It is situated in the path of the old emigrant trail and for 50 years home seekers have been exploring its valleys and fording its rivers, yet in all that time less than one million acres of agricultural land have passed into the hands of private individuals through the operation of our public land laws. During much of that time the laws providing for the requirement of title to land were much more liberal than they are at present. The best locations for reclaiming land have all been utilized. The streams which could be diverted at small cost are nearly all fully appropriated or over appropriated. If such inadequate results have characterized the favorable conditions of the last half century what can we expect under the same laws for the future?

I ascertained after the publication of the paper from which you have quoted, that the table giving acreage of taxable lands is in one particular incorrect. I gave the area of patented land as the taxable area, but since its publication I have learned that railway land grants are taxed whether patented or not. At the time the paper was prepared I believed that these lands stood on exactly the same footing as land filings under other laws and were not taxable until patents has issued, but by legislation in 1886 this was changed. The taxable area in the land grant states is, therefore, as much greater than my table as the difference between the railroad lands which have been patented and the total grant. In several of the states it does not materially affect the percentages and does not at all affect the conclusion as to the adequacy of the land laws, but rather emphasizes it.

Respectfully, Elwood Mead.
Cheyenne, Wyo., Dec. 7, 1896.

A CONVENIENT METRIC CONVERSION TABLE.

The following metric conversion table has been compiled by Mr. C. W. Hunt, M. Am. Soc. M. E., president of the C. W. Hunt Co., of New York city, and is the most labor-saving tool in the dealing with metric weights and measures which we have anywhere seen. We advise our readers to paste this convenient and compact table in their note-books. For the benefit of those of our readers who preserve their copies for binding, we would add that Mr. Hunt has had copies of this convenient table printed on a slip with a gummed back, and will, we presume, mail one of these to any of our readers on request.

Millimeters × .03937 = inches.
Millimeters ÷ 25.4 = inches.
Centimeters × .3937 = inches.
Centimeters ÷ 2.54 = inches.
Meters × 39.37 = inches. (Act of Congress.)
Meters × 3.281 = feet.
Meters × 1.094 = yards.
Kilometers × .621 = miles.
Kilometers ÷ 1.6093 = miles.
Kilometers × 3280.7 = feet.
Square millimeters × .0155 = square inches.
Square millimeters ÷ 645.1 = square inches.
Square centimeters × .155 = square inches.
Square centimeters ÷ 6.451 = square inches.
Square meters × 10.764 = square feet.
Square kilometers × 247.1 = acres.
Hectares × 2.471 = acres.
Cubic centimeters ÷ 16.383 = cubic inches.
Cubic centimeters ÷ 3.69 = fluid drachms. (U. S. P.)
Cubic centimeters ÷ 29.57 = fluid ounce. (U. S. P.)
Cubic meters × 35.315 = cubic feet.
Cubic meters × 1.308 = cubic yards.
Cubic meters × 264.2 = gallons (231. cu. in.).
Liters × 61.022 = cubic inches. (Act Congress.)
Liters × 33.84 = fluid ounces. (U. S. Phar.)
Liters × .2642 = gallons (231 cubic inches).
Liters ÷ 3.78 = gallons (231 cubic inches).
Liters ÷ 28.316 = cubic feet.
Hectoliters × 3.531 = cubic feet.
Hectoliters × 2.84 = bushels (2150.42 cubic inches).
Hectoliters × .131 = cubic yards.
Hectoliters ÷ 26.42 = gallons (231 cubic inches).
Grammes × 15.432 = grains. (Act Congress.)
Grammes × 981 = dynes.
Grammes (water) ÷ 29.57 = fluid ounces.
Grammes ÷ 28.35 = ounces avoirdupois.
Grammes per cu. cent. ÷ 27.7 = lbs. per cu. in.
Joule × .7373 = foot pounds.
Kilograms × 2.2046 = pounds.
Kilograms × 35.3 = ounces avoirdupois.
Kilograms ÷ 1102.3 = tons (2,000 lbs.).
Kilograms per sq. cent. × 14.223 = lbs. per sq. in.
Kilogrammeters × 7.233 = foot pounds.
Kilograms per meter × .672 = pounds per square foot.
Kilograms per cubic meter × .026 = pounds per cu. ft.
Kilograms per cheval vapeur × 2.235 = lbs. per HP.
Kilo-watts × 1.34 = horse power.
Watts ÷ 746 = horse power.
Watts ÷ .7373 = foot pounds per second.
Calorie × 3.968 = B. T. U.
Cheval vapeur × .9863 = horse power.
(Centigrade × 1.8) + 32 = degrees Fahrenheit.
Francs × .193 = dollars.
Gravity, Paris = 980.94 centimeters per second.

THE MECHWART ROTARY PLOWING MACHINES WITH STEAM AND PETROLEUM MOTORS.

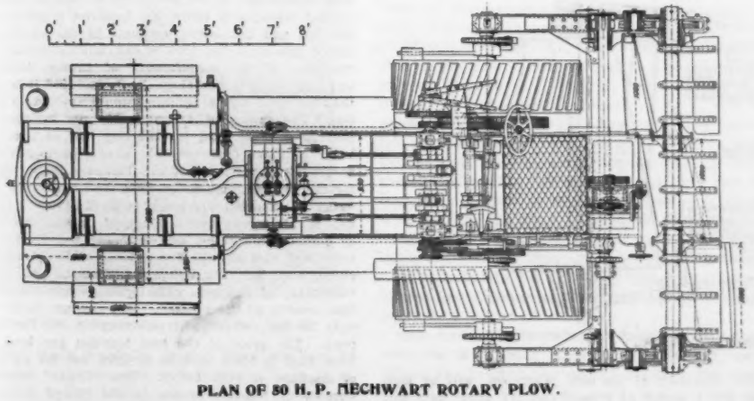
The first steam plow was patented in England in 1846, and since that date machine plowing has been attempted, with more or less success, in every country where the importance of agricultural methods and the areas to be cultivated would warrant the necessary outlay. The first so-called steam plows were nothing more than a system of ordinary gang-plows hauled backward and forward across a field by ropes operated by stationary engines placed on each side of the field. Owing to the practical difficulties encountered this method has been very generally abandoned, and a traction engine was next used to haul after it a series of gang-plows. Many other plowing devices have been since patented, including so-called digging and spading devices, some of these being hauled by rope or by horses, and others being mounted directly in the rear of a traction engine and forming part of the engine. But mechanical defects, the softness and unevenness of the ground, the lack of uniformity in the depth of the cut made, and the usually high cost of these machines, coupled with unsatisfactory results, have prevented them from coming into general use.

MECHWART ROTARY PLOW.
Operated by 50 H. P. Steam Engine.

The requirements for a direct-acting rotary steam plow may be generally stated as follows: The machine must be strong, compact, easily repaired and not too expensive in first cost or daily operation; the plow must cut out a clean, compact mold, lift this out of the ground without disturbing the subsoil, and deposit this mold to the rear of the machine in a thoroughly loosened and inverted condition; the gage of the traction engine must be less than the width of the cut made so that the main wheels may always travel upon firm ground, and the depth of the cut made must be capable of adjustment, to suit the ground, and this depth must be automatically controlled by the ground surface itself.

Rotary steam plows have been heretofore made; but these generally operated a series of narrow spades, upon a drum, which simply loosened the soil and scattered it about unevenly. To meet each and every one of the above requirements the rotary steam plow here illustrated has been invented and patented by Mr. Andreas Mechwart, the general manager of Ganz & Co., an important manufacturing concern of Budapest, Hungary. The practical needs of a machine of this character have been so carefully studied that this plow promises to revolutionize present practice in this connection.

As shown in the illustrations, the rotary plows are directly connected with the engine operating it and also supplying the motive power. The frame supporting the plows is pivoted to the main axle of the locomotive, and by special devices is made to automatically adjust the depth of cutting to the inequalities of the surface. To prevent one falling mold from interfering with the cutting of the next mold, by the following share, and to make the cutting without shock, the cutting edge of the share is given a shearing action by setting it at an angle to the axis of the drum, this angle approximating 30°, but varied to suit the soil. The peculiar form and angle given these shares enables them to lift the cut molds bodily and to deposit them rearward in an inverted position; and the claim is made that no other rotary plow accomplishes this important result. As the plows rotate in the same direction as the main running wheels, the pushing action of the plows in the ground practically assists the forward motion of the locomotive and to that extent decreases the tractive force required.



PLAN OF 50 H. P. MECHWART ROTARY PLOW.

At the Budapest Exposition of 1896 the Mechwart plow was exhibited under running conditions. This plow, shown in the half-tone illustrations, was operated by a 50 HP. steam engine used to propel the plow and to rotate the cutting or plowing device. The plow, or cutter-drum, was 12 ft. long, with an outside diameter of 3 ft., and the cut made was from 6 to 14 ins. deep, according to the adjustment of the apparatus. Many previous tests made with this same machine, and in different soils, show that the action of the plows is similar in effect to the spading operation in garden work. Crops of wheat, barley, oats and corn, raised on soil thus treated, are claimed to have yielded from 5 to 15% heavier weight of product than similar crops raised from ground worked by the ordinary gang plow. This plowing machine has also been worked in combination with a harrow and cultivator hauled after it with no added expense.

The Mechwart plowing machine is made in three sizes of 30, 40 and 50 HP., plowing over a space 8, 10 and 12 ft. wide and having a working capacity, in 14 hours, of 14, 18 and 21½ acres. The weight of a 50 HP. machine is 10 tons, and the selling price of this class of machine is $4,000. An elaborate estimate puts the total cost of operating a 50 HP. plow at $16.80 per day; in this estimate the day is 14 hours long, coal costs $2.50 per ton, the engineer and fireman are paid $2.50 and $1.50 per day and the fuel consumed is 275 lbs. per hour. With an average of 21½ acres per day plowed 14 ins. deep the average cost of plowing per acre is 78 cts.

Cuts on the next page show a similar but smaller rotary steam plow operated by a 12 HP. petroleum motor, as exhibited at the Budapest Exposition. This motor was especially designed to work automatically and to be safe from explosion, smell or smoke. The petroleum vapor is carried automatically from a tank on the machine, without the use of a supply pump, and the ignition is brought about without the use of an electric spark or burning flame. An engineer is not needed, as any man or boy can soon be taught to operate the motor.

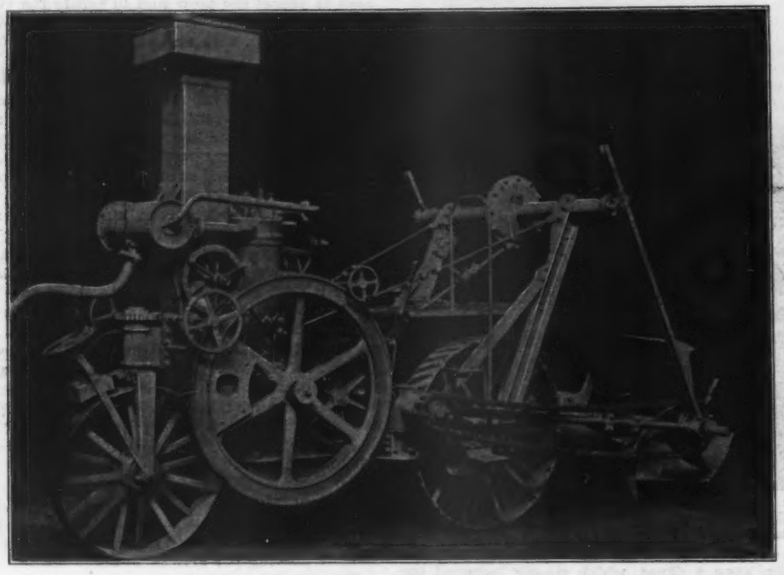
Sections Showing Principle of Cut Made by the Mechwart Rotary Plow.

In this petroleum plowing machine the circular cutter is 4 ft. wide and 3 ft. in diameter; but provision is made to insert a 5 or 6 ft. cutter when this is deemed necessary. The plow will cut from 6 to 12 ins. deep, as the soil may require, and it may be worked in a train with a harrow and cultivator. This machine has plowed an average of 8 acres, 12 ins. deep, in 14 hours. The machine is sold for $800, and the average daily cost of operation, including the investment, is put down at $3.78. In this estimate 1½ gallons of petroleum are used per hour and two farm laborers are included at $1 per day. On the above basis of 8 acres plowed 12 ins. deep in 14 hours, the average cost per acre is only 47 cts. Both machines are patented in the United States, and for further information the reader is referred to the American representative, M. Neumayer, M. E., C. E., 68 East 114th St., New York city.

THE NEW NORTHWEST WATER-WORKS TUNNEL for Chicago, Ill., is progressing quite satisfactorily, according to recent reports. Of the total 72,600 ft. of land tunnel, 5,600 ft. of the 10-ft. tunnel and 11,435 ft. of the 8-ft. tunnel have been completed. Of the lake tunnel, 10-ft. in diameter, about 800 ft. are completed.

STANDARD CEMENT SPECIFICATIONS OF THE SOUTH AUSTRALIAN GOVERMENT.

We are indebted to Alexander B. Moncrieff, M. Inst. C. E. and Engineer-in-Chief of the South Australian Government, for a copy of the standard specifications for Portland cement supplied to that government for use on its public works, under which he states satisfactory material has been received for some time past. These specifications are interesting in themselves, and



MECHWART ROTARY PLOW.
Operated by 12 H. P. Petroleum Motor.

show recent engineering practice in Australia in regard to cement.

The part of the specifications relating to weight, residue, sand, mixing and tests is as follows:

Weight—ascertained by filling a cylindrical, imperial bushel measure from a fixed hopper which will deliver the cement at a height of 2 ft. above the bottom of the measure. The measure, which is 13 ins. high, will be set upon a solid floor, and shall be filled in two minutes. No shaking or other means will be allowed to cause the cement to settle. The weight of the "striked" bushel shall be not less than 100 lbs.; and the specific gravity of the cement not less than 3.10. The tests for weight and specific gravity shall be made not earlier than 28 days after the cement has left the contractor's works.

Residue—ascertained by sifting 10 lbs. through a sieve of 5,806 meshes per sq. in., made of wire No. 45 I. S. W. G., shall not be more than 1 lb., and all this residue shall pass through a sieve of 2,500 meshes per sq. in., made of wire No. 39, I. S. W. G.

Sand—used for the tests shall be River Torrens sand, thoroughly washed and dried, all passed through a sieve of 400 meshes per sq. in. and caught on a sieve of 900 meshes per sq. in.

Mixing—will be effected in a Faija's mixer, the proportions of cement, sand and water being determined by weight and all the water being added at once.

Test blocks—or briquettes will be made by filling the material, mixed as above, into metal molds of the form shown in the margin,* and resting on non-absorbent beds, and pressing it uniformly so as to exclude the air and make the briquette compact.

The pressure shall be applied by hand to each briquette for not more than 2 minutes for neat cement, and 3 minutes for cement and sand, and the pressure shall not exceed 56 lbs. upon a tool similar to that shown below.

The blocks shall be kept in the molds exposed to the air for 24 hours, and then in water for the balance of the specified periods, when they shall be taken out and immediately tested.

Testing of the blocks will be done in a testing machine approved by the Engineer-in-Chief. The strain on each block commencing from 0 lbs. and increasing at the uniform rate of 400 lbs. per minute until the block is broken.

Tensile strength per sq. in. of neat cement, 7 days after mixing, shall not be less than 400 lbs.

Tensile strength of neat cement, 28 days after mixing, shall not be less than 550 lbs. per sq. in.

Tensile strength per sq. in. of a mixture of 1 part of cement to 3 parts of sand, 28 days after mixing, shall not be less than 200 lbs.

Setting and Cracking Test.—Pats of neat cement, about 3 ins. in diameter and ½-in. thick, with thin edges, will be mixed on glass with sufficient water to form a stiff paste, and the times of setting hard enough to support ¼-lb. on a wire 1-12-in. diameter, and 1 lb. on a wire 1-24-in. diameter shall not be less than 1 hour and 3 hours, nor more than 4 hours and 12 hours respectively. One-half of the pats, when set, will be kept in water for a period of 7 days and the other half will be exposed to the air, and if distortion or cracking of edges develops in them, the cement from which they were taken will be rejected.

In addition to the above tests the Engineer-in-Chief may order such chemical tests and analyses as he may think necessary to demonstrate whether or not the article supplied contains the requisite constituents of Portland cement.

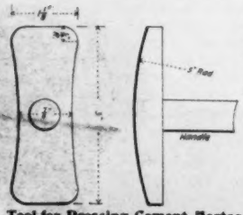
Four samples at least for each test shall be obtained from every 400 bushels for the purpose of testing.

In the event of a sample failing to stand any of the required tests, the Engineer-in-Chief shall have the option of ordering fresh tests at the expense of the contractor, or of rejecting the whole of the parcel from which such sample was obtained.

All costs of testing shall be borne by the contractor. The charge for testing the samples representing each 400 bushels shall be one guinea.

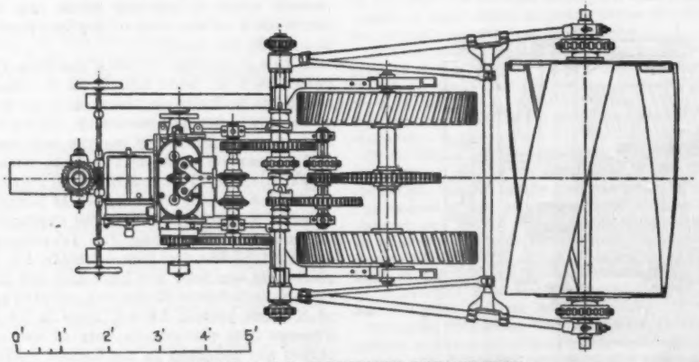
Should the contractor request in writing any further tests, the charge for making each such additional test shall also be one guinea.

It is not intended that there shall be any departure from the established departmental mode of testing, but if any test be objected to by the contractor on the alleged ground of insufficient pressure being used in filling the mold, and he request that a further test be made the pressure shall in such further test be applied by a machine rolling a tool, similar to that shown herewith, over the surface of the mixture, under a direct dead-weight of 56 lbs. The time occupied in filling each mold in such case shall not exceed 3 minutes for neat cement and 4 minutes for cement and sand.



Tool for Pressing Cement Mortar into Briquette Molds.

In further clauses it is specified that while the tests shall be made at such place and in such manner as the Engineer-in-Chief may direct, the contractor has the option of being represented at the testing. No cement will be received that has not been properly cooled and aerated before delivery; and the contractor must stack the cement in separate lots of 400 bushels each, estimating about 4 bushels of cement to each barrel or 2 bushels to each sack. From each lot so stacked at least four samples will be taken by boring with an auger into several packages, or by other approved means. No delivery will be considered complete without the certificate of the Engineer-in-Chief that the cement is of the required standard; nor will any payment be made on account of cement delivered without the production of this certificate. Tenderers must give the schedule price per imperial "striked" bushel of Portland cement as measured upon completion of 28 days' test. This price must include all patent rights and royalties, packages, carriage, testing, and "any claims whatsoever arising from the making, conveyance, stacking and delivery of the cement, in accordance with the terms of this specification."



PLAN OF 12 H. P. MECHWART ROTARY PLOW.

*This is practically the Am. Soc. C. E. section.—Ed.

THE CYCLE INDUSTRY IN THE UNITED States, says an interesting and lengthly article on this subject in the London "Times," has grown from 6 factories, in 1885, with a total output of 11,000 machines, to 500 factories in 1895, counting only those which turn out not less than 1,000 machines annually, and having a total production of 600,000 cycles of various grades. The capital invested in these 500 factories is placed at $90,000,000, and the lowest estimate of the output of completed machines for 1896 is one million valued at $30,000,000. If the manufacture of tubing, bells, lamps, and other bicycle paraphernalia is included it is estimated that the total capital invested would amount to $125,000,000. The export of American bicycles practically commenced in 1895, and for the last half of that year the value of those exported only amounted to $243,721, according to the reports of the Treasury Department. But for the first six months of 1893 the same report puts the value of exported machines at $1,654,291. Nearly one-half of this export goes to England, incompleted machines or parts of machines, and Germany and France are the next best customers. The success of the American machine, says the "Times," is the attention paid to the development of strength with lightness and the finish and high quality of the product. Bicycles are made weighing only 26 lbs., which will safely carry 300 lbs. over any road. The price of the best bicycles has been reduced from $140 in 1893, to $100 in 1896, for the same quality of machine or even better. The "Times" estimates the number of bicycles in use in the United States at not less than 3,000,000. Mr. George F. Parker, American Consul at Birmingham, says that in 1895 about 750,000 bicycles were made in England, valued at about $58,392,000. The export value of English bicycles for the first 9 months of 1896 amounted to $6,452,691; but the trade in cycle material with the United States has declined to $62,787, and Mr. Parker says it will practically cease by the end of the season of 1897.

AUTOMATIC BUCKET FOR COAL HOISTING; SOUTHERN PACIFIC RY. DOCKS, OAKLAND, CAL.

In a paper in a recent number of the "Journal of the Association of Engineering Societies," Mr. John D. Isaacs, of the Technical Society of the Pacific Coast, described certain apparatus designed by him for handling coal for the Southern Pacific Ry. Co. at Port Costa and Oakland Wharf. The bucket used is particularly interesting, and it was devised to meet peculiar conditions existing at that point. These conditions required that most of the coal should be landed from ships into receiving bunkers and then transported by rail to the place of consumption. The high cost of coal, the high rate of wages paid to stevedores, and the importance of quickly unloading the vessels made it very desirable that waste and breaking should be diminished as far as possible, that manual labor be minimized in handling the coal and that the ship be discharged quickly.

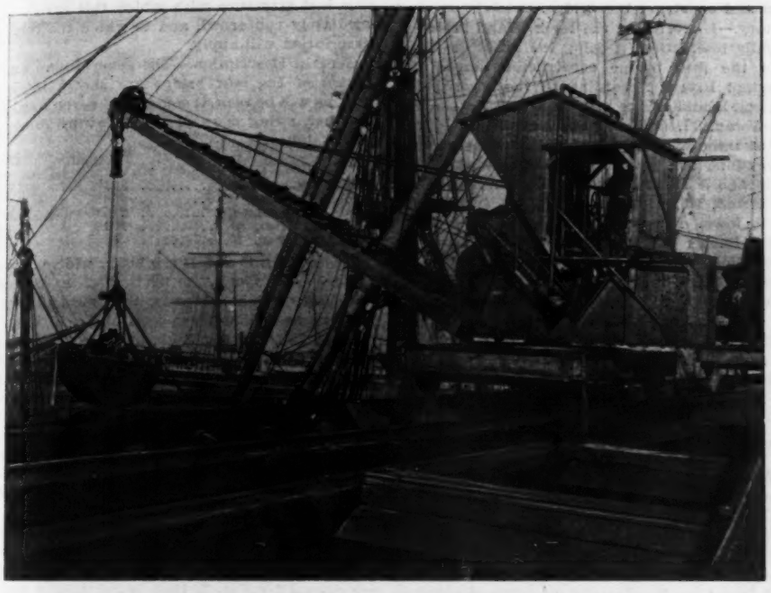


FIG. 1.—COAL UNLOADING PLANT AT SOUTHERN PACIFIC RY. DOCKS; OAKLAND, CAL.
Designed by John D. Isaacs, M. Am. Soc. C. E.

The mechanical digging conveyor, supplemented by a fore-and-aft conveyor in the ship bringing coal to the main buckets, is the ideal method of landing coal from vessels and in some form is in common use in the Eastern and Middle States for unloading barges. But on the Pacific Coast there are complications which make this system practically impossible. The coal ranges in size from dust to pieces measuring several cubic feet in volume; it is sometimes very wet and at other times very dry; the range of tide, the variation in the draft of ships and in the size and position of the hatches, and the interference of rigging and special bulkheads would all interfere with the proper working of the conveyor system. The only practical method of general application is the hoist of a bucket by means of a derrick of some form; and it was to the improvement of this latter method that Mr. Isaacs directed his attention.

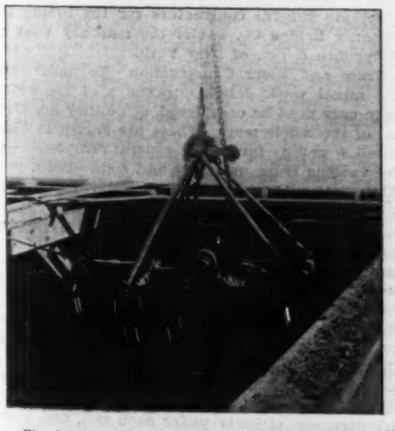


Fig. 2.—View of Automatic Coal Bucket, Closed.

The ordinary "tipper" bucket involves much manual labor and a high dump for the coal; consequently many varieties of clam-shell dredger, or "grab-buckets" as they are there called, have been devised. These buckets should be simple, with few parts and these easily replaced; they should be moderate in cost, with a low repair account; they should be geared to bite lumps of coal in two when these are caught between the lips; they should bury themselves in the coal and come up full; have a low dump and be handled entirely by the derrick engineer. The buckets which conformed most nearly to the conditions of low dump, automatic action and applicability to various states of the coal, says Mr. Isaacs, were very complicated in their gears, springs, pawls, etc., and caused constant delay and expense in repairs.

The grab-bucket designed by him and here illustrated, is only limited in size by the dimensions of the hatches and the capacity of the derrick. Three sizes have been made, of 3,000, 3,800 and 5,000 lbs. capacity, level full; but the medium size meets the conditions and is now the only size in use. It weighs 3,775 lbs., with a ratio of dead weight to useful load, of about 1 to 1, and has a capacity of 64.4 cu. ft. The maximum speed of lift is about 400 ft. per minute, and the average fall of coal is 8 ft., as compared with 21 ft. from the tipped bucket. In operating it, only one stevedore is required at the hatch, instead of six as with the tipper. Five of these grab-buckets have been in almost constant use at the Oakland Wharf since November, 1894; and to this time there has been absolutely no delay by disarrangement and there have been no charges against them for repairs.

This bucket is operated as follows: It is lowered into the hold, both lines being paid out together. When the bucket has nearly reached the coal, the running line is let go, and the weight of the lower sheaves, hinges, etc., throws the bucket wide open by the time it rests upon the coal. The hanging line is now slacked and the running line hauled in, and the bucket buries itself in the coal, up to the lower sheave-shaft, and closes. Both lines are now hauled in together, but the lift is kept entirely on the runner. As soon as the bucket clears the hatch it begins to swing and hoisting is stopped as it clears the top of the bunker and it then passes to the point of discharge. At this latter point the hanging line is held and the runner released, opening the bucket and dumping the coal; and with this latter operation a reverse motion towards the ship begins.

Fig. 3.—View of Automatic Coal Bucket, Open.

The derricks employed in handling these buckets are of the ordinary type, with double independent drums, friction brakes and the usual appliances. The reach of the boom is 32 ft. The derrick car runs on a track of 8 ft. gage, and is hooked down to the track stringers when in use. All lowering is done by the brakes. In the same paper Mr. Isaacs describes and illustrates the receiving and distributing bunkers built at Oakland and at other points. These bunkers have each a capacity of 10 tons per foot run, level full. They contain an average of 1,266 ft. B. M. of timber per foot run and cost by contract about $36.60 per foot. The trestle approach contains 266 ft. B. M. and it cost $6.60 per lineal foot. The track on the top of the bunker is 46 ft. above the coaling track, which is outside of the bunkers, as giving the greatest capacity for a given height and width.

COMPARATIVE VALUES OF GAS AND ELECTRICITY FOR HEAT, LIGHT AND POWER IN GERMANY.

At the last meeting of the German Union of Gas Manufacturers, says "Le Genie Civil," Mr. W. G. Oechehauser gave some comparative figures relating to the cost of gas and electricity for lighting, heating and power purposes. These figures, which are based solely upon German practice, are as follows:

In gas lighting, under ordinary pressure one cubic meter of gas ordinarily furnishes 560 Hefner units. In using the incandescent electric light, with lights of 16 candle-power, it is usual to rate one kilo-watt hour as giving about 280 Hefner units. On this basis one cubic meter of gas is equivalent to two kilo-watt hours. With the arc light compared with gas, one cubic meter of gas, under a pressure of one meter, furnishes 1,000 Hefner units; and one kilo-watt also gives 1,000 Hefner units. In this case one cubic meter of gas is about equivalent to one kilo-watt hour. For lighting purposes one cubic meter of gas, in Germany, costs from 3½ to 5 cts., while the cost of a kilo-watt hour is from 15 to 20 cts.

For power purposes, one effective horse-power hour, according to the power of the motor, requires an expenditure of gas varying from 600 to 800 litres; one cubic meter of gas can thus be rated as furnishing from 1.25 to 1.66 horse-power hours.

In electric power, one effective horse-power hour is equal to 736 watts; and in the actual electric motor the mean useful effect varies from 80 to 90%, according to their power. They absorb then from 820 to 920 watts per horse-power hour produced, and one kilo-watt produces from 1.08 to 1.22 horse-power hours. In this case again, one cubic meter of gas is approximately equivalent to a kilo-watt.

For heating purposes, the experiments of Messrs. M. J. Hasse and F. Goly show that the combustion of one cubic meter of gas furnishing 2,400 to 2,600 effective calories in gas-cooking appliances; 3,840 calories in heating water for baths, and from 3,628 to 4,080 calories in general gas heating apparatus. For heating by electricity, Messrs. F. H. Haasse and A. Herzberg figure that we can utilize from 80 to 95% of the product. On this basis one kilo-watt will only produce from 700 to 800 effective calories.

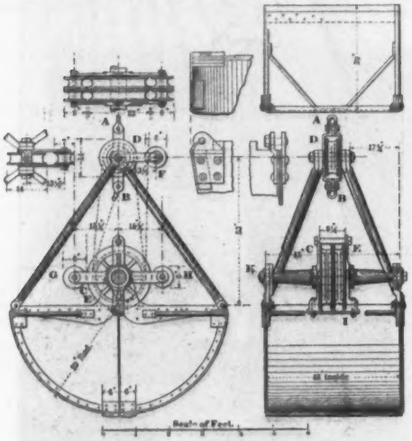


Fig. 4.—Details of Automatic Coal Bucket.

The ordinary German price for gas supplied for heating and power purposes varies from 2 to 3 cts. per cubic meter; under similar conditions the cost of a kilo-watt varies from 5 to 7½ cts.

THE MANAOS TELEGRAPHIC CABLE, laid in the Amazon River, to connect Para and Manaos, cost $1,000,000 and failed to work within 31 days after being laid. It was guaranteed for only 30 days by the contractor. No messages have been transmitted over it since last February; but it is being inspected for breaks and it is hoped that it may be in operation again before long. This cable was supposed to supplant the overland telegraph line to the center of the rubber trade; a line continually interrupted by the rapid growth of tropical vegetations and the antics of Brazilian monkeys.

A FRENCH-SOUDAN RAILWAY, or, rather, the completion of a railway commenced in 1881, is being considered by the Colonial Minister of France. Up to 1896 $2,600,000 had been expended on a line extending from Kayes to Bafoulabe, with a proposed extension to the Niger, with the practical result that about 56 miles of rails have been laid down on ties spaced about 16 ft. apart, with the rails held by single bolts. Surveys have now been completed to the Niger, and a project for finishing the road has been favorably reported upon by the Minister. The two towns mentioned are on the Senegal River, emptying on the West Coast of Africa at St. Louis, and between Bafoulabe and the Niger, emptying into the Gulf of Guinea, lies high and difficult ground. The opinion is advanced that the proposed line is a simple waste of human energy and the hard-earned money of too sanguine investors.

DOUBLE DECK HIGHWAY AND RAILWAY BRIDGE ROCK ISLAND, ILL.

(With inset.)

The Rock Island Bridge, whose principal structural features are illustrated in the accompanying engravings and on our inset sheet this week, is one of the most important bridge structures constructed in the United States during the past year. Briefly described it is a combination railway and highway bridge 1,850 ft. long over all with seven fixed spans and one swing span; the highway being carried on the main floor at the bottom chord line and the two-track railway line upon a second floor 12½ ft. in the clear above the highway. The bridge crosses the Mississippi River, between Rock Island, Ill., and Davenport, Ia., and has been built at the joint expense of the United States Government and the Chicago, Rock Island & Pacific Ry., the railway company paying 60% of the cost. Accurately speaking, the bridge has been constructed by the United States Government and 60% of its cost, by agreement, charged to the railway company. A. R. Buffington, Colonel of Ordnance, U. S. A., Commanding Officer, Rock Island Arsenal, was the Government representative having the work in charge, and he appointed Mr. Ralph Modjeski, Assoc. M. Am. Soc. C. E., Chicago, Ill., as Chief Engineer, to design and construct the bridge.

History.—Historically, the Rock Island bridge is unusually interesting, it being the lineal descendant of the first bridge constructed across the Mississippi River. According to the records the first Rock Island bridge was built under a charter granted Jan. 17, 1853, by the Legislature of the State of Illinois. The purpose of its construction was to connect by spanning the Mississippi River the Chicago & Rock Island R. R. terminating at Rock Island, Ill., with the Mississippi & Missouri R. R. in Iowa. It was the first bridge to be built over the Father of Waters and the opposition by the so-called "river interests" to its construction and maintenance was most bitter and prolonged. However, the bridge was finally built—a single track, wooden, Howe truss structure—and served its purpose until on May 6, 1856, when the first span, east of the swing span, 250 ft. long, was destroyed by fire, communicated by the steamboat "Effie Afton," which collided with and burned at one of the piers. In the litigation which followed, and which was brought by the owners of the burned boat, it is of interest to note that Abraham Lincoln, of Springfield, Ill., was one of the counsel for the railway company.

This did not end the troubles of the bridge, however, for in 1860, a suit was brought by James Ward, a citizen of St. Louis, Mo., which resulted in Judge Love, of the District Court of the United States for the District of Iowa, declaring the bridge a "nuisance" and ordering "all the piers within the state of Iowa, together with the superstructure thereon, removed on or before the 1st day of October next." As denoting the opinion of those days regarding the comparative importance of the railway and the navigation interests, it is interesting to note, among other things in Judge Love's decree, the statement that, "if the bridge were to remain, we would probably in no great period of time have railway bridges upon the Mississippi River at every 40 or 50 miles of its course;" also, "that the loss involved in the removal of this bridge would be but trifling compared with the great mischief which must inevitably flow (to the commerce of the river) from the precedent of maintaining it." In one respect the prediction of Judge Love has been in a great measure realized, for at this time there are at least 35 railway and highway bridges over the Mississippi River between Minneapolis, Minn., and St. Louis, Mo., a distance of 800 miles. However, to return to the subject, the Supreme Court of the United States reversed the decision of Judge Love, principally on the ground that the jurisdiction of the District Court extended only to the middle channel of the river, and the removal of the three piers in the State of Iowa would not remedy the obstruction, while it would destroy the bridge.

This decision seems to have settled the trouble from litigation, and in 1866 and 1867 two acts were passed by Congress authorizing the construction of a new bridge to replace the old one. Before work was begun, however, the bridge had suffered serious accidents. In March, 1868, the first pier on the Iowa shore was pushed bodily some 20 ft. or 30 ft. downstream by the ice, and in April of the same year, during a severe wind storm, the swing span was lifted from its masonry and blown over on its side upstream, so that it hung supported by the pier with both ends free in midair. In June, 1869, the contract for the masonry for the new bridge was let, and the structure was completed in October, 1872. Mr. C. Shaler Smith, M. Am. Soc. C. E., was Chief Engineer, and the Phoenix Bridge Co., of Phoenixville, Pa., the contractors for the superstructure. Nineteen years after the completion of the new bridge it was found necessary to strengthen the upper or railway floor, and in 1891 the wooden system then in use was replaced by iron construction. Despite these repairs, however, the bridge was inadequate to the traffic, particularly to the railway traffic, there being but one line of track and no great surplus of strength for the heavier and more frequent trains. In 1894-95, therefore, Congress authorized an entirely new superstructure and partly new substructure, and appropriated the sum of $490,000 for the work. It is this last structure with which this article is immediately concerned, and to which the remaining description will apply.

General Description.—The general plan and elevation of the new bridge are shown by Fig. 1, and, as will be seen, it consists of seven fixed spans and one swing span of the following dimensions and weights:

	Length, ft.	Length, ins.	Weight, lbs.
One swing span, A	365	7	2,490,271
Two fixed spans, B	258	0	3,208,955
Three fixed spans, C	216	6¾	3,630,815
One fixed span, D	193	3	780,142
One fixed span, E	98	9	337,779

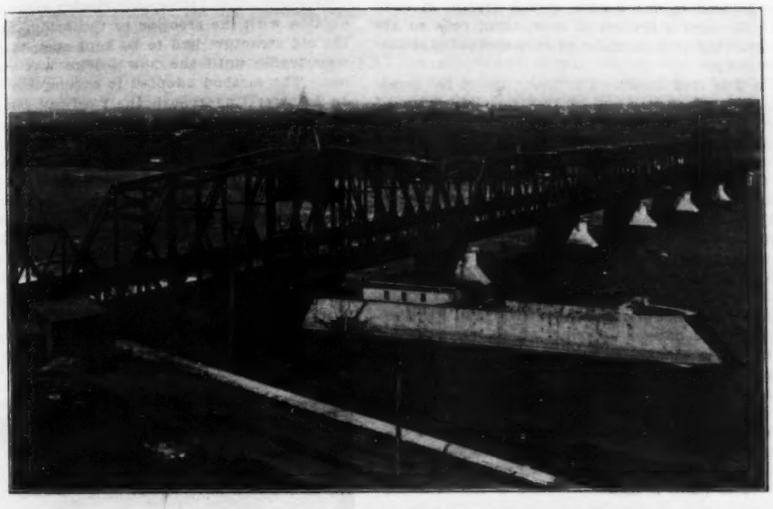
Spans A, B, C and D are 29 ft. wide, c. to c., of trusses, and span A is 62 ft. high at the centre and 50 ft. high at the ends. Spans B and C are 50 ft. high at the centres; span D, 30 ft. high, and span E, 25 ft. 4½ ins. high, but only 28 ft. wide, c. to c., of trusses. All spans carry a roadway at the lower chord line 226 ft. wide, with two 6 ft. sidewalks, and a two-track railway line on an upper deck. The styles of truss and lateral bracing, with one exception, which will be noted further on, are shown by the drawings as is also the location of the piers and other general features.

Substructure.—It having been determined to utilize the old piers for the new bridge, and this structure being considerably wider than the old one, it became necessary to remodel the masonry to suit new conditions. This was done in the manner shown by Fig. 2, that is the coping and top part of the old pier was removed down to a point where by interrupting the batter of the old cutwater and extending it upward vertically the increased width obtained would be sufficient for the new conditions. For the old piers Joliet limestone had been used, but the new masonry was composed of Kettle River sandstone for the facing and coping and of Anamosa stone backing, laid in Alsen's Portland cement mortar, of two parts sand and one part cement, for the facing, and three parts sand and one part cement for the backing. The specifications for the masonry required tests of the stone and were rigidly drawn to secure the best workmanship, but need not be given in detail here. As general contractors for the bridge the Phoenix Bridge Co. sublet the masonry work to Sooysmith & Co., of New York.

Truss and Floor Construction.—To understand the metal work details, drawings of the swing span only need be considered, since they are typical of the whole work. These are shown in Figs. 3 and 4, and as far as the general composition of the various truss members and connections, portal and lateral bracing, characteristic strains, etc., are concerned, they are self-explanatory. Some of the minor requirements in the metal work construction will be noted in the abstracts of the specifications given further on. In the roadway floor construction no unusual design is found, it being a simple floor beam and girder construction, with the necessary flooring and paving for wagon traffic, and with two lines of street railway track. The railway deck floor and track construction, however, demand further notice. Transverse girder floor beams carry four lines of grider stringers, one stringer under each rail, and these stringers carry a solid floor of trough sections of the form shown in detail in Fig. 5. The Phoenix Iron Co., of Phoenixville, Pa., made special rolls for this trough section. A detail of the connections of the floor troughs, stringers and floor beams at each floor beam is shown by Fig. 6. The floor troughs are, of course, riveted to the stringers in the manner indicated by Fig. 5. On top of the floor troughs and under each rail is a 20 × ⅜-in.

plate continuous the whole length of the bridge and, of course, riveted to the floor troughs. The object of the continuity of these plates was that in connection with the floor troughs they might form a lateral bracing against wind pressure. The troughs take the shear and the continuous plates act as chords to take the bending moment. On the top of these plates at each trough top there is an 8½ × 8 × ⅜-in. steel blocking plate to support the rail, and to their inner edges, that is between rails, a guard angle is riveted as shown by Fig. 3. Altogether this floor weighs 940 lbs. per lin. ft. It is also water-tight to protect the roadway floor below.

In calculating the various members the following loads were used: Dead load, span A, 7,380 lbs. per lin. ft. of bridge; span B, 7,220 lbs.; span C, 6,700 lbs.; span D, 4,000 lbs.; span E, 3,400 lbs. Live load for trusses, 80 lbs. per sq. ft. or 3,050 lbs. per lin. ft. for roadway and 4,000 lbs. per lin. ft. per track for railway deck; live load for roadway floor, Cooper's road roller and electric car, each 12 tons in 7½ ft., or 100 lbs. per sq. ft., and for railway floor the locomotive and car load shown by Fig. 7. The wind load was placed at 650 lbs. per



DOUBLE DECK RAILWAY AND HIGHWAY BRIDGE, ROCK ISLAND, ILL.
Ralph Modjeski, Assoc. M. Am. Soc. C. E., Chief Engineer.

lin. ft. at the railway deck, 300 lbs. at bottom chord, and 200 lbs. at top chord.

Turntable.—The general dimensions and construction of the turntable and drum are shown by Figs. 3 and 4. The track-bed plates are of tough gray cast iron, and are planed top and bottom to a uniform thickness. The tread segments are of forged steel, and planed to uniform thickness and bevel. The wheels are of cast steel.

Material.—Generally all structural plate and shape work is of medium open hearth steel and all rivets are of soft open hearth steel, except the trough floor, which was made of soft steel. Cast steel is used for end bearings, turntable wheels and other parts of the machinery; cast iron for bed plates and certain portions of the machinery, and wrought iron for the spider rods of the turntable and minor parts. The specifications were in abstract as follows:

Steel shall be made by the open hearth process. The amount of phosphorus shall never exceed 0.08% in acid steel and 0.04% in basic steel. The variation in cross section or weight of rolled material shall never be more than 2½% from the specified dimensions and weights. Steel pins over 4 ins. in diameter shall be hammered. In tests the following requirements shall be met:

	Med. steel, lbs.	Pin. steel, lbs.	Soft steel, lbs.
Minimum ultimate strength	63,000	63,000	54,000
Maximum ultimate strength	71,000	71,000	62,000
Minimum elastic limit	38,000	38,000	32,000
P. C. elongation in 8 ins.	22	18	28
P. C. reduction of area	44	36	52

(A somewhat higher elastic limit, it will be observed, was adopted.—Ed.)

All material must be perfectly straightened—mill straightening will not be considered as sufficient—and the templets shall not be applied to any material unless it is perfectly straight. They must lay flat without distortion while the marking is being made. The diameter of the punch shall be at least 3-16-in. smaller than the finished hole in all material ¾-in. or less. It shall be ⅛-in. smaller than the diameter of the finished hole in material ¾-in. to 1 in. in thickness. No punching will be allowed in material thicker than 1 in. The diameter of the die shall, in no case, be more than 1-32-in. in excess of the diameter of the punch. After the pieces have been punched or drilled, they shall be assembled and the holes reamed or drilled to the required size. The punching must be sufficiently accurate to permit 1-16-in. of metal to be taken out all around the hole by reaming. Otherwise a smaller punch shall be used. No drifting shall be allowed which would cause initial strains in any of the assembled pieces. The reaming shall be done in a neat manner, taking out 1-16-in. of metal all around the hole. While the reaming is being done the different pieces shall be held firmly together by bolts and clamps. After the pieces are reamed, every hole shall be gone over with a counter-sinking tool, cutting off the sharp edge of the hole, and making a fillet of about 1-16-in. under each rivet head. The members shall then be taken apart and cleaned, the surfaces in contact painted, and the members carefully reassembled and riveted up before the paint is dry. The diameter of the rivets will be such as to require, when heated, a slight pressure to force it into the hole. The size of the rivets shall be adjusted to fill this condition. Whenever possible the riveting shall be done by power. The manufacturer shall procure special riveting machines to meet special positions. All rivets shall have hemispherical heads of neat and workmanlike appearance concentric with the axis of the rivet hole. They shall be well up against the metal. The rivets shall fill the holes and be absolutely tight. No calking or recupping will be allowed. Counter-sunk rivets shall be so driven as to fill the counter-sunk holes completely, and in such a manner as to dispense with chipping when possible. All chipping, whether of rivets or other parts, shall be done in a neat and workmanlike manner without breaking out of metal. Each chipped surface shall be finished off with a file. Where metal is chipped or planed out of a plate or shape, all sharp or concave corners shall be rounded off to at least a 2-in. radius. (This requirement is unusually novel. To understand its application reference may be made to Fig. 4, where the plate X has its corner chipped and rounded according to this clause.—Ed.) No chipping shall be done with a sledge hammer.

Forged Work.—All steel heated for the purpose of forging, bending, or up-setting, shall be subsequently annealed by heating to a dark red heat and allowing to cool slowly. The heads of eye-bars and screw-ends shall be up-set by a process acceptable to the commanding officer. No welds will be allowed except in wrought iron. The design of the heads of eye-bars may be determined by the contractor, provided this design is uniform throughout for each width of bar, and provided the head is strong enough to break the body of the bar. The head will never be more than 1-16-in. thicker than the body of the bar.

Machine Work.—All sheared edges or ends of plates or shapes shall be planed or faced so as to take off at least ¼-in. of metal. No sheared or punched surface shall be left in the work. Curved edges may be chipped and filed unless specified to the contrary. The ends of riveted chords shall be faced after they are riveted up complete, excepting the projecting splice plates. The lengths shall be measured with iron standards. The chords shall be provided with suitable spacing blocks and clamps, especially near each end, to hold the plates and angles firmly in their proper relative positions while the ends are being faced. The chord sections shall be fitted together at the shops in lengths of at least 120 ft. When so fitted together there shall be no perceptible wind in this length. The reaming of the splices, as well as all other field connections, shall be done with the different parts assembled. When this is impracticable, the connections shall be reamed through iron templets at least 1½ ins. thick. The parts which have been reamed together shall be stamped with stencils, and marked with white paint in such a manner as to be easily put together in the field in the same relative position. Diagrams for marking shall be furnished by the commanding officer or by the inspector. The angles for cross frames, portals and laterals may be reamed from iron templets, provided that one cross frame of each kind, one portal of each kind, and one panel of lateral angles of each kind is fitted up in the shop complete. When so fitted the rivet holes must come truly opposite each other; otherwise the different pieces must be assembled for reaming. All pin holes shall be bored with a sharp tool. A finishing cut shall always be taken. The finished pin hole shall be perfectly smooth and polished. Roughness in a pin hole shall be sufficient reason for rejecting a whole member. The distance between pin holes shall be measured with an iron standard of the same temperature as the member. The plans show the distance between the centers of pin holes; shop measurements shall be made between the bearing surfaces of tension or compression members, with a proper allowance for the diameter of the pin. Pin holes shall be bored exactly square with the member and absolutely parallel with each other. The play of the pins in the pin holes shall never exceed 1-50-in. This applies to all pin holes in the structure, and must be strictly adhered to. Machine fitted bolts must fill the holes with a driving fit. All pins shall be accurately turned to a gage and shall be full size throughout. Pins above 5 ins. in diameter shall be bored through center as shown on plans. The ends of stringers and floor beams shall be squared in the facer. The end angles must be so fitted that facing does not reduce the thickness of the angles by more than ⅛ of their original thickness. The cut will extend over the whole surface of the angles. The stringers shall be measured with an iron standard and must be absolutely true. All bearing surfaces shall be truly faced. All machine-finished surfaces shall be covered with a thick coat of white lead and tallow before leaving the shop. All machine work shall be performed in the best possible manner and according to plans, whether specified here or not.

Eye-bars.—Eye-bars, after being annealed, shall be bored with a sharp tool at exact distances. The pin holes shall be perfectly square with the face, and exactly on the axis of the body of the bar. Roughness in the pin hole shall be sufficient reason for rejecting a bar. The distance between pin holes of each bar shall be tried with an iron standard of the same temperature as the bar. There shall be no perceptible difference in the length of the bars in the same billed length. The play of the pins in the pin holes shall never exceed 1-50-in.

Full-sized Tests.—There shall be 12 full-size eye-bars tested to destruction. The sizes of test bars shall be determined by the engineer in charge. The 12 tests shall be divided into four groups of three tests each. When a full set of eye-bars of the same dimensions as one of the test bars has been manufactured and annealed, the inspector shall select a test bar from that set. When three test bars have been selected in this manner, they shall be tested without delay. The three tests will then constitute a group. No bars known to be defective in any way shall be taken for test bars. Such defective bars

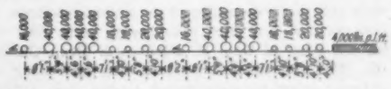


Fig. 7.—Locomotive Diagram for Live Load, Rock Island Bridge.

shall be rejected. If tested by the manufacturer the results shall in no way influence the acceptance or rejection of other bars. The tests of full-size bars shall be made at such place as the commanding officer of Rock Island Arsenal may direct. They shall meet the following requirements:

Minimum ultimate strength	60,000 lbs.
Minimum elastic limit	33,000 "
Minimum elongation for each bar	10%
Average elongation for a group of three tests	12%

The elongation shall be measured in 20 ft., including the fracture. The bars will be required to break in the body. When a bar breaks in the head, but develops 10% elongation, another bar of the same size and lot shall be tested, the two tests being counted as one. If the average elongation of these two tests attains 12%, the test will be considered as satisfactory; provided, however, that no more than one bar of each group of three tests breaks in the head. In case of an unsuccessful group of tests, the engineer in charge, under direction of the commanding officer, shall examine the cause of the failure and determine which bars shall be rejected. If the bars fail in the ultimate strength, elastic limit, or elongation, the engineer in charge may reject all bars of the same melt as the defective test bar, whether already manufactured or not, or he may reject the whole bill of eye-bars. The commanding officer of the Rock Island Arsenal may, however, order additional tests. If, in a group of three tests, more than one bar breaks in the head, all bars presented by this group of tests shall be rejected. If a test bar is too long for the machine, it shall be cut in two and both halves reheaded, annealed and tested; the two tests, however, to count as one. If the cross-section of a test bar is too great for the capacity of the machine, it shall be planed down on a length of 10 ft. to a section equal to the capacity of the machine in pounds divided by 75,000, and then tested to destruction, care being taken to have all corners and angles at the places of change of section carefully rounded off. The elongation shall then be measured in 8 ft. One clevis and one sleeve nut of each size shall be tested coupled to corresponding bars. They will be required to break the bar. The bars used for these tests shall be of steel accepted for this work.

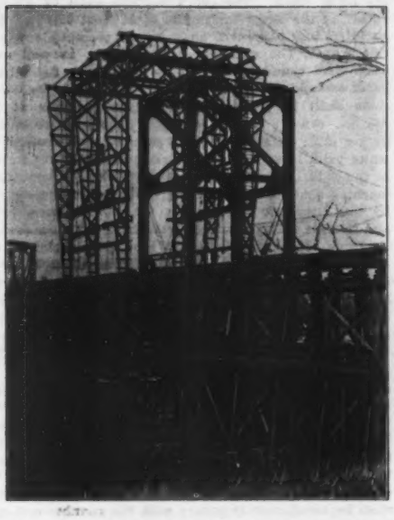


Fig. 8.—View of Falsework and Traveler Used in Erection.

The specifications have been quoted thus fully because they indicate more clearly than could be easily done in any other way the quality of workmanship and material, which are among the notable features of the bridge. In their rigidness and regard to detail they are worthy of careful study, and are characteristic of the best character of government work.

Operating Machinery.—It is not possible at the present time to give detail drawings of the operating machinery, which is in many respects novel, but the following general description in connection with the details shown by Figs. 3 and 4 will give a very fair understanding of its salient features. The contractors for this machinery were the well known firm of Geo. P. Nichols & Bro., Chicago, Ill. For the present purpose the operating machinery may be considered under five different headings, as follows:

(1) The Swinging Machinery Proper.—The rack attached to the tread on the center pier is made of cast steel, and instead of having teeth of the usual form, is made wih sprockets. On each side of the drum are two vertical shafts, supported by brackets, on the lower end of which shafts are cast steel sprocket wheels corresponding in pitch with that of the rack, which is 12 ins. These sprocket wheels carry an endless chain, with links of 12 ins. pitch, which engage the sprockets on the rack. On the upper end of these vertical shafts are sprocket wheels, which are connected by a chain to a vertical driving shaft midway between them, which rises to the floor of the machinery room. This is duplicated on the opposite side of the bridge. An interesting feature of this part is that all these vertical shafts are run on ball step bearings. On the upper end of these main vertical shafts above the machinery floor are bevel gears, one looking up and the other looking down, the two being connected through bevel pinions to a horizontal cross shaft, divided in the center where an equalizing gear is attached. By means of a train of gears a 50 HP. electric motor is connected with the shaft, thereby transmitting the power to the rack below. All the machinery in the room is mounted on one common bedplate.

(2) Rail Locks.—On each of the four ends of the tracks on the bridge are a system of rail locks consisting of heavy steel slides fitted to the outside of the rails and held in position by guides, so that they may be slid into position or withdrawn, thereby connecting the ends of the rails on the bridge with those on the fixed span, so that the wheels of the train will pass over the intervening gap on these slides without any jar, a continuous line being presented on which the wheels pass. These slides are operated by means of a pneumatic cylinder located in the center of the bridge at each end, through a system of connecting rods so arranged that all four slides at each end move simultaneously.

(3) The End Jacks.—The jacks are of the semi-toggle type, consisting of two parallel pairs of bars attached to the end beams directly under the chords by pins so as to turn freely, while on the lower end are rollers which rest on bearing plates on the shore abutment. By means of a pneumatic cylinder, a center crank and struts connected to the roller pins, these jacks are forced to a vertical position when the bridge is closed, and drawn in to release the bridge when it is to be opened.

(4) The Interlocking and Controlling System.—A Hall signal is placed on each of the fixed spans within a few feet of the ends of the draw, standing normally at danger. Connected to each of the jacks and rail locks are electric switch boxes, from which wires run through insulated pipes to an indicator in the machinery room. When any one or all of the jacks or rail locks are in a closed position, a red lamp is lighted in the indicator, one lamp for each jack or pair of rails, and when they are released for the bridge to swing, a corresponding white lamp is lighted, replacing the red. By a combination of electric connections, the man in charge of the bridge can set the signal to safety only when the end jacks and rail locks are set. Should for any reason the bridge not be properly locked, the engineer cannot receive his signal to enter upon the draw.

At the front end of the machinery room, in a bay window from which the operator can have a clear view of the tracks and river, is placed an interlocking controlling stand, having four levers, the first one to the right operating a hand brake. The second lever controls the rail locks through an air valve, and can be moved at will; this being thrown forward, the end jack lever which previously has been locked is released, the movement unlocking the motor controller lever, which now can be moved for operating the bridge. This system makes it impossible for the operator to swing the bridge until first the rail locks and then the end jacks have been released, the indicator above referred to announcing to the operator that these various devices have properly responded to the movement of his levers.

In the machinery house is also an air compressor, driven by an electric motor, and in the attic above the machinery room are two steel reservoirs of a combined capacity of 200 cu. ft., from which air is drawn to operate the various cylinders. A uniform pressure of 120 lbs. is maintained by an automatic device whereby the pump is started automatically when the pressure falls below 110 lbs. and stops when it reaches 120 lbs.

Electric current for swinging the bridge is furnished from the power station of the Tri City Ry. Co., whose wires pass directly over a support on the bridge; also from the Peoples' Power Co. of Moline, Ill., whose wires are brought up to the same support on the bridge. By means of a system of rings and brushes, current is taken from these wires are brought to the switch board in the machinery room, where a double throw-switch is placed so that the motor may be connected either with the railway wires or those of the People's Power Co. at will.

(5) Emergency Hand Devices.—To guard against any possibility of the bridge being made inoperative through any cause, a supplementary hand connection has been made for each separate device. To swing the bridge a capstan is placed underneath the roadway deck at each end and attached to the floor beams. Eye bolts are fastened in the masonry at the abutment, and at the ends of the stone protection. A heavy hawser stored on a platform near the capstan is attached to these eye bolts in case of emergency and the rope reeved around the capstan. By means of a lever this capstan can be operated by hand and the bridge opened and closed. Connected with the center crank which operates the end jacks at each end is a worm gear, to which the same lever which is used to work the capstan can be attached and the jacks may thus be raised and lowered in case of necessity. On the railway deck the rail lock system is also provided with levers so as to work independently of the air, should occasion arise.

Erection.—The principal difficulty arising in connection with the erection of the bridge was that the old structure had to be kept open to the railway traffic until the new bridge was ready for use. The method adopted to accomplish this was as follows: Underneath the roadway floor of the old bridge was built a falsework, and on top of this falsework were placed trestle bents inside the trusses and carrying the upper or railway deck. This allowed every part of the old structure except the railway floor to be removed. Since the new bridge was double tracked and the old bridge single tracked, the new trusses came outside of the old trusses. Outside of the new trusses came the traveler tracks. Obviously the falsework was made much wider than the old bridge. The photograph, Fig. 9, indicates the construction just described. The method of procedure was to remove span by span the old structure, except the railway floor, and to replace it by the new structure, the railway floor of the new structure being the last part to go into place.

End View of Swing Span, Rock Island Bridge.

Engineers and Contractors.—The Rock Island bridge was built after the designs and under the supervision of Mr. Ralph Modjeski, Assoc. M. Am. Soc. C. E., of Chicago, Ill., as Chief Engineer. Col. A. R. Buffington, Ordnance Corps, U. S. A., was the representative of the United States Government. Mr. E. H. Connor was Resident Engineer, and Byron B. Carter, Mechanical Engineer. The general contractors for the bridge were the Phoenix Bridge Co., of Phoenixville, Pa., John Sterling Deans, M. Am. Soc. C. E., Chief Engineer. The subcontractors for the substructure were Sooysmith & Co., of New York. The contractors for the operating machinery for the swing span were Geo. P. Nicholas & Bro., Chicago, Ill.